SECTION 2

Communication Technologies

Few technologies have changed our world as much as communication technologies. They have streamlined publishing techniques and allowed us to produce more accurate drawings. They have expanded our entertainment choices. They have enabled us to contact people thousands of miles away. The chapters in this section will discuss the uses of communication technologies.

Technology and Society

The Paperless Office?

Many predicted that computer usage would reduce our need for paper. Well, virtually every desk in the industrialized world has a computer on it. Sales of plain white paper continue to climb.

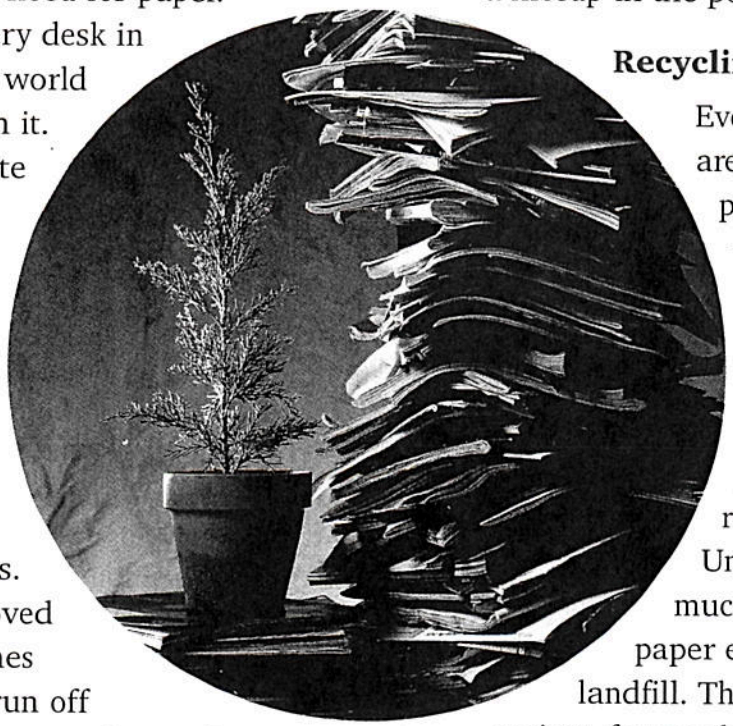
One reason for these paper sale increases is the appeal of laser and inkjet printers driven by desktop computers. Meanwhile, improved photocopy machines make it easier to run off copies. According to a Gallup poll, the paper-eating/paper-spewing fax machine is the favorite means of communication in corporations. It is preferred over voice mail, e-mail, and overnight courier.

Not surprisingly, sales of file cabinets rose 30 percent during the first half of the 1990s.

Paper Doesn't Crash

One notion about electronic documents has become commonplace. We take it for granted that computers can suddenly fail. These four words are now a universally accepted excuse for delay: "The system is down."

People despise "paperwork." However, they know it won't disappear because of a hiccup in the power grid.



Recycling Fever

Even though people are using more paper, they feel they should be using less. Two-thirds of large businesses collect office paper for recycling. Unfortunately, much of this collected paper ends up in the landfill. The toner used in copiers, fax machines, and printers is difficult to scrub out. Researchers are pursuing a process to break down toner. Such a process would help us recycle more paper, even if we can't begin using less paper.

Linking to the COMMUNITY

Observe users of a photocopy machine in a busy office, store, or library. Keep a count of how many good copies are made versus rejected copies. Compare your results with the observations of others.

CHAPTER 3

Computer-Aided Drafting (CAD)

OBJECTIVES

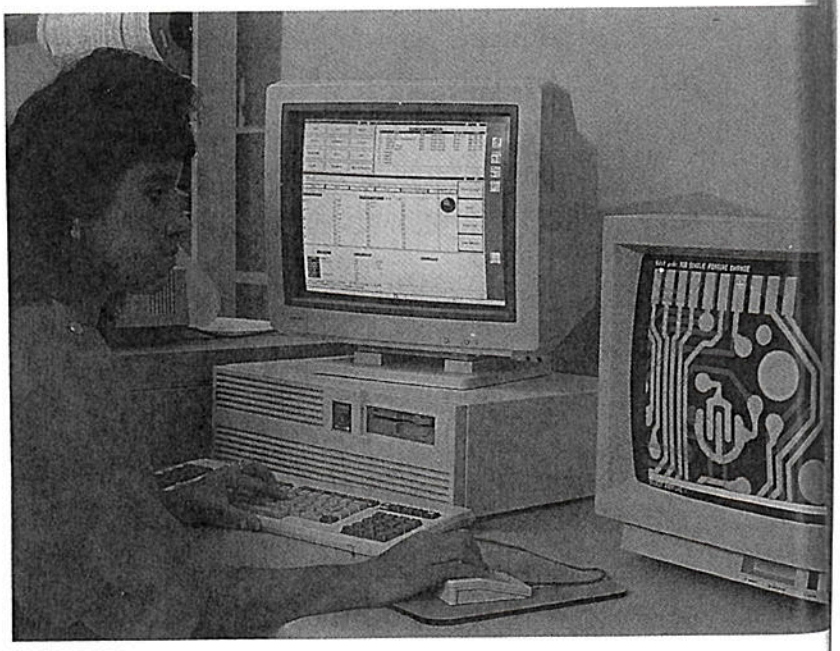
- explain the advantages of CAD.
- identify the components of a CAD system.
- discuss how CAD is used in industry.
- describe the basic CAD system commands.

KEY TERMS

CAD/CAM
Cartesian coordinate system
command
computer-aided drafting (CAD)
coordinate pair
drafting
random-access memory (RAM)
read-only memory (ROM)

Do you enjoy drawing? Even if you don't, you probably realize that drawing is an important form of communication. Drawings have always been used to record ideas.

Architects use drawings to show how to construct buildings and what materials to use. Civil engineers draw the plans for new roads and other projects like bridges and water treatment plants. Electronic engineers use drawings to show the circuits of new computers and stereo systems. Many successful products began as sketches on a scrap of paper.



FASCINATING FACTS

Thomas Jefferson, the third President of the United States, was a skilled drafter. He prepared plans for Monticello, his Virginia home. He also prepared plans for the University of Virginia.

CAD ADVANTAGES

Drafting is the process of representing three-dimensional objects in two dimensions. Drafting is called the language of industry. Traditional drafting is done directly on paper. The tools used are drafting machines, pencils, rulers, triangles, erasers, and compasses. Today, traditional drafting is being replaced by computer-aided drafting (CAD).

Computer-aided drafting (CAD) is the process of using a computer to create drafted documents. In this chapter, you will learn about the CAD system components, the different types of CAD, and the basic CAD commands.

CAD has a number of advantages over traditional drafting. Using up-to-date hardware and CAD software, a drafter can prepare drawings much more quickly than by manual drafting. Here's an example: Suppose an architect is drawing plans for a home that has ten identical windows. Using traditional drafting techniques, the same window would have to be drawn ten times. When a CAD system is used, the desired window can be retrieved from a *library*. It can then be placed in the ten locations in a matter of seconds.

CAD drawings are neater and more accurate than manually prepared drawings. Fig. 3-1. For example, CAD drawings can be accurate to more than 1/10,000 of an inch. Even highly skilled drafters cannot work to that degree of accuracy.

Corrections to manually prepared drawings are made with an eraser. CAD drawings never need erasing. Changes are made on-screen.

Manually preparing additional original drawings is a time-consuming process.

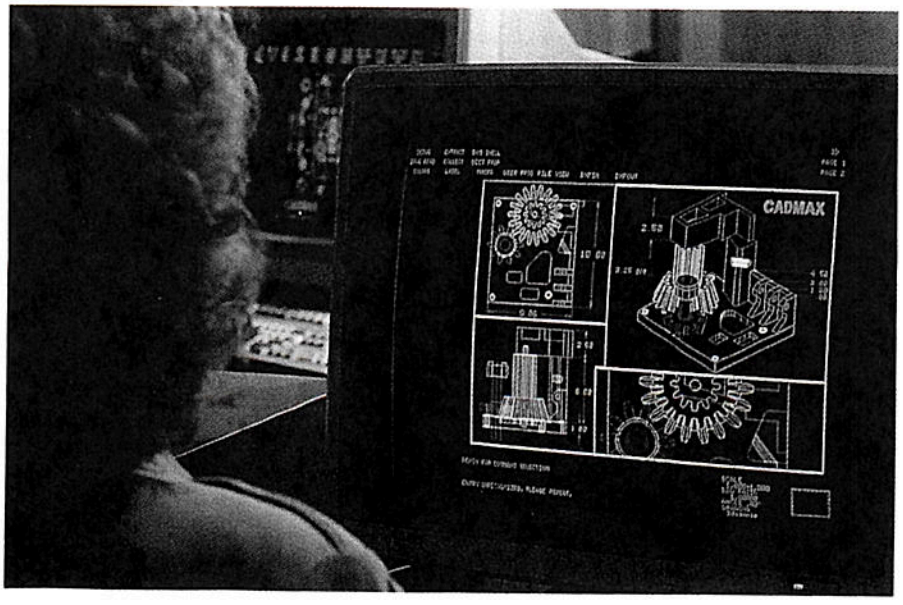


Fig. 3-1 Using CAD software, drawings can be prepared with great precision. Details can be changed more quickly and easily than on drawings prepared by traditional drafting methods.

Because CAD drawings are electronically stored and retrieved, additional copies can be produced quickly.

Despite CAD's many advantages, it is important to remember that drawings created using CAD reflect the talent and skill of the designers and technicians who use the systems. CAD systems help designers and drafters be more productive. However, these systems can't change a poor design into a good one.

CAD SYSTEM COMPONENTS

CAD systems need two components—hardware and software. The hardware includes the computer itself. It also includes the devices used to enter (input) information into the computer, and devices used to display (output) the drawings. CAD software is the computer program that enables a computer to be used as a drawing tool.

Hardware

The *central processing unit (CPU)* is the "heart" of the computer. It determines the speed of the computer. This affects how quickly the computer can process information. CAD work requires a fast, powerful computer.

Computers have two types of memory. **Read-only memory (ROM)** is permanent memory. It usually includes the computer's operating system. **Random-access memory (RAM)** is temporary memory. Many CAD programs require a computer with at least sixteen megabytes of RAM.

Information is entered into the CAD program through an input device. The keyboard and mouse are examples of input devices. In CAD, the *digitizing* (DIJ-uh-TIE-zing) *tablet* and its *puck* are important input devices. The puck is moved on the digitizing tablet. The puck resembles a mouse, but is much more accurate. The puck has crosshairs that are used to mark points accurately. Fig. 3-2. The digitizing tablet is also called a *digitizer*. A digitizer can also be used to enter an existing drawing into a CAD system.

A monitor displays the drawing while the CAD operator works on it. Large monitors are preferred for CAD work.

Computer data is stored in a number of different ways. Hard disk drives store the computer's operating system, software programs such as CAD, and information in the form of files. Drawing files require a lot of room on the hard drive. Many programs are now provided on CD-ROM (compact disc read-only memory) rather than on floppy disks. Floppy disks provide convenient and inexpensive storage for data.

One advantage of a CD-ROM is that it can store a large amount of data. Today, most personal computers cannot save data to CD. However, this is expected to change. Tape drives and removable hard drives are used when large amounts of data must be saved.

Printers and plotters transfer the drawing to paper. These drawings are called "hard copy." Standard laser printers are usually not used for printing CAD drawings. They can print only relatively small drawings. Plotters that use ink pens, felt-tip markers, or ink jets are used to produce most CAD drawings. Fig 3-3.

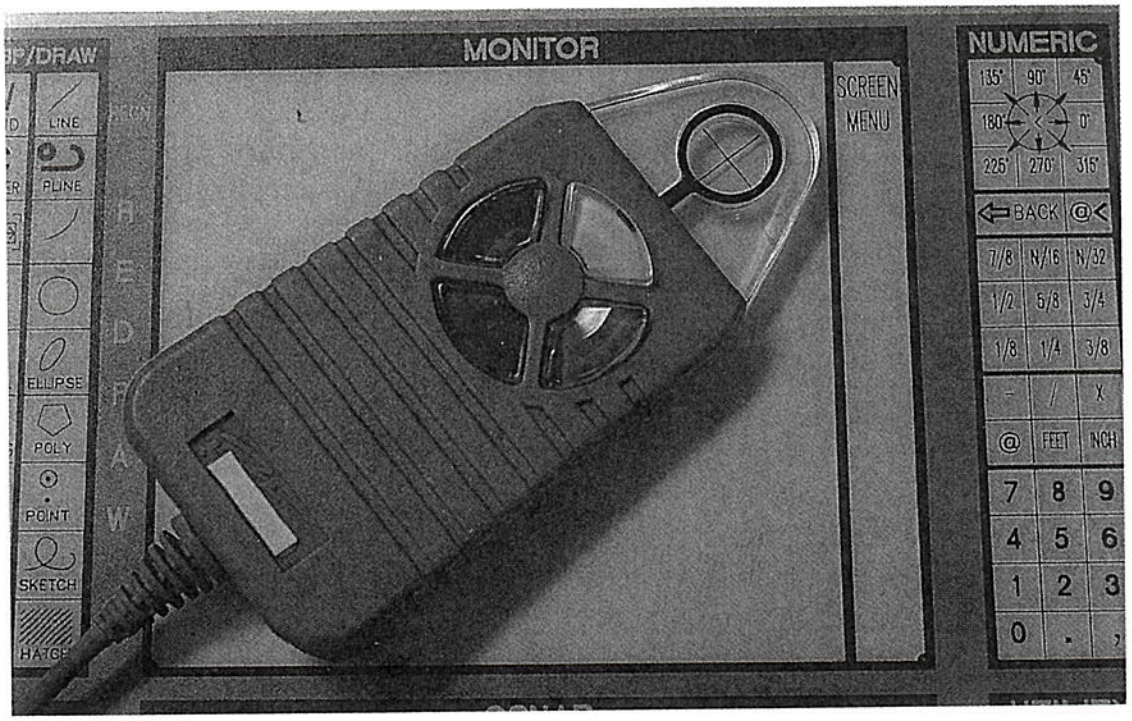


Fig. 3-2 The puck, shown here on the digitizing tablet, is moved over the tablet to place points on the drawing. The movements of the puck on the digitizing tablet are tracked on the computer screen.

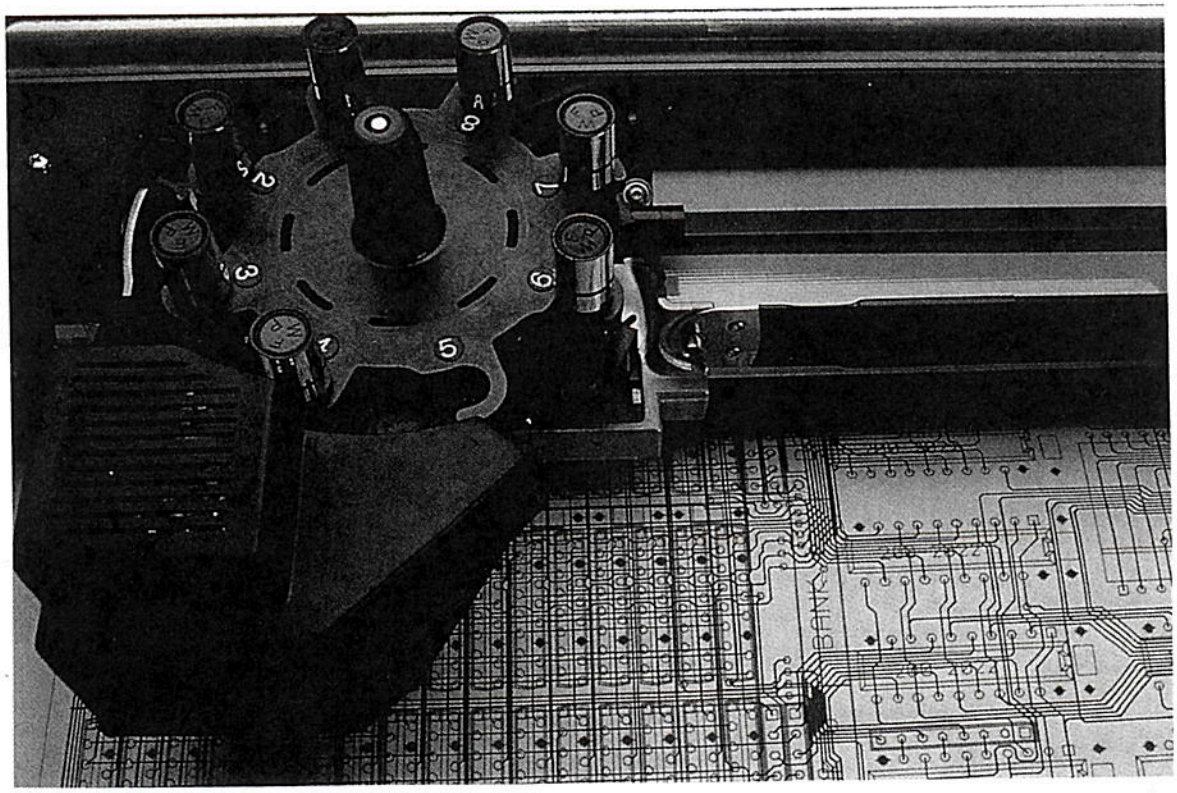


Fig. 3-3 An electronic pen on a plotter. The pen can operate at 24 inches per second. Optional sensors set the pressure, height, and speed of the pen.

Software

Dozens of different CAD programs are available. Some of the programs can be used by beginners. Others require that users have extensive training. CAD software developers regularly release new versions of their programs. They also offer training at technical colleges throughout the United States.

Before purchasing CAD software, make sure that it includes all the needed features. Check to be certain that the software will work with the hardware you plan to use. Also, find out if the software company offers technical support and regular upgrades.

CARTESIAN COORDINATE SYSTEM

CAD systems produce accurate drawings because the user can select exact points, such as the ends of lines and the centers of circles. The system used is called *Cartesian* (kahr-TEE-shun) *geometry.*

The **Cartesian coordinate system** is a system that allows you to plot points on a drawing. The system is based on an imaginary grid. For two-dimensional drawings the grid has two axes, the X axis and the Y axis. (*Axes* is the plural of *axis*.) The X axis is used to plot width. The Y axis is used to plot height. A third axis (Z), showing depth, can be added for three-dimensional drawings.

Figure 3-4 shows the Cartesian coordinate system. The X axis and Y axis are at right angles to each other. They meet at a point called the *origin*. Note that each axis has a positive (+) side and a negative (−) side. Note also that the axes create four imaginary *quadrants* (KWAD-runt). A quadrant is one-quarter of a circle.

To locate any point, you need to specify two numbers. Assume that the numbers are 4 and 2. These numbers (4,2) are called a coordinate pair. A **coordinate pair** is a set of two numbers that will locate a point on a grid. The first number (4) is the X coordinate. The second number (2) is the Y coordinate. If (2,4) is used as the coordinate pair, will a different point be selected?

Linking to MATHEMATICS

Plotting Coordinates. In the Cartesian coordinate system, the X value is always the first number. The Y value is the second number in the pair (X, Y).

In the example (3,5), 3 would be the X coordinate; 5 would be the Y coordinate.

If the third-dimensional Z axis is used, the number to be plotted on that axis is the third number. In the example (X, Y, Z), Z would represent the Z axis.

Use an 8" x 11" sheet of 1/4" grid paper. Place the X axis horizontally in the center of the page. Place the Y axis vertically in the center of the page. Label the X axis and Y axis. Write the positive and negative numbers from the origin on both axes. Plot the following points. Then connect them in order of plotting.

1. (0,4)
2. (3,2)
3. (4,0)
4. (3,-2)
5. (0,-4)
6. (-3,-2)
7. (-3,2)
8. (0,4)

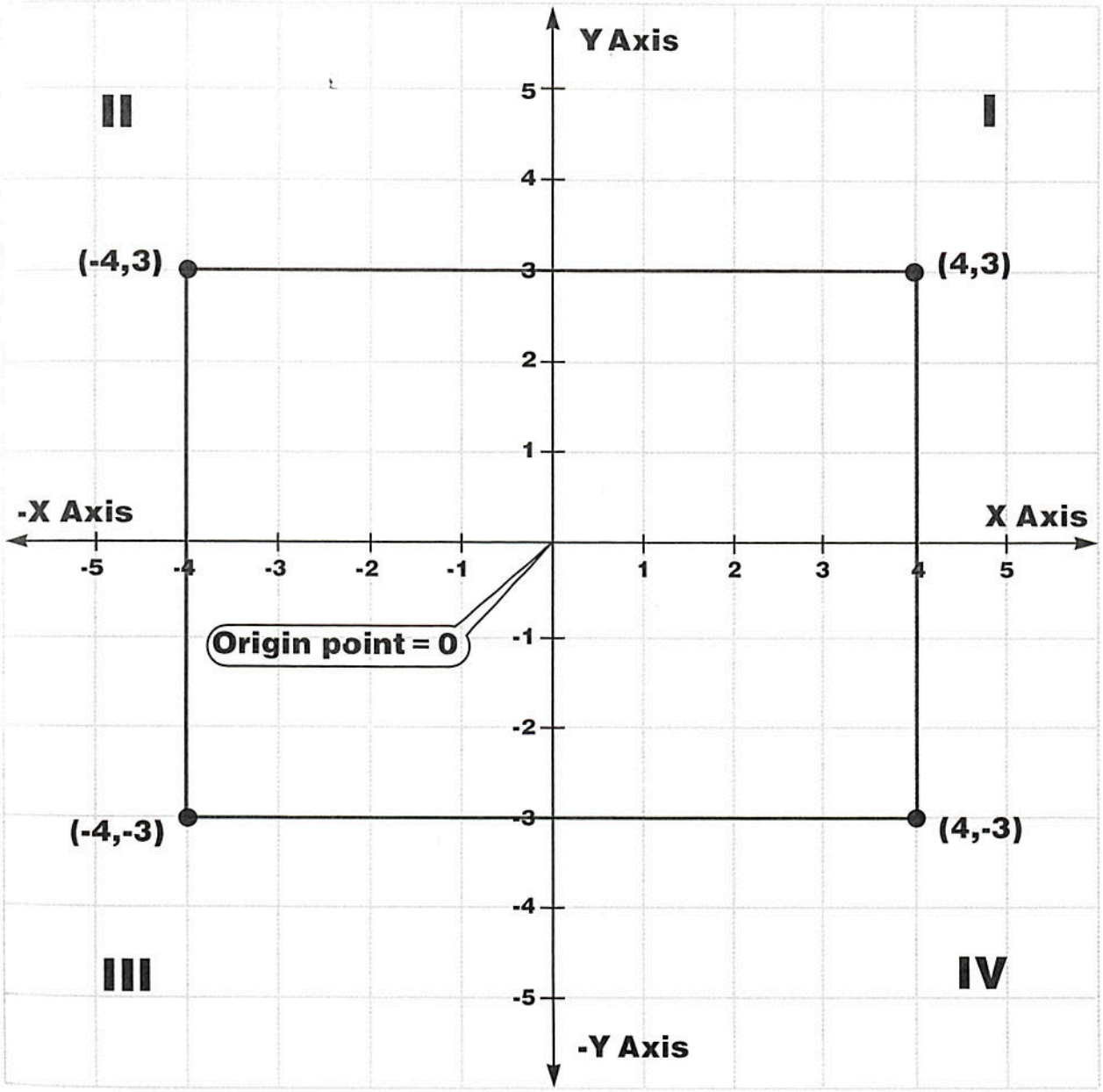


Fig. 3-4 The Cartesian coordinate system is the key to plotting points on a CAD drawing.

TWO-DIMENSIONAL AND THREE-DIMENSIONAL CAD DRAWINGS

A two-dimensional drawing shows width and length or width and height or length and height.

Most CAD programs can quickly create a three-dimensional drawing from one that is two-dimensional. They do this by adding depth. Depth is the Z axis in the Cartesian coordinate system. The drawing in Fig. 3-5 is two dimensional. Which dimensions does it show?

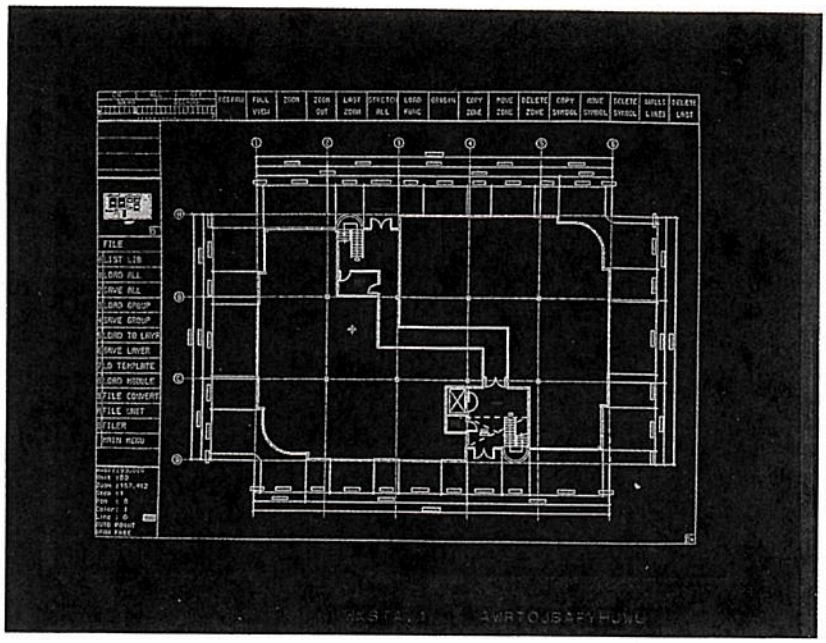


Fig. 3-5 A two-dimensional CAD drawing.

Figure 3-6 shows the Z axis. It also shows how the Cartesian coordinate system can be used to draw a rectangle. Three important kinds of three-dimensional CAD drawings are wireframes, surface models, and solid models.

Linking to SCIENCE

Beam Strength. A beam is a structural support. For example, a beam is used in a simple form of the bridge. You can study the forces on a beam bridge using a wooden yardstick. Place two chairs back to back about a foot apart. Bridge them with the yardstick. Gently press the center of the yardstick until the wood bends slightly. Now move the chairs another foot apart to make a longer model bridge. Is less or more force required to bend the yardstick? Now turn the yardstick on its edge and apply force. How does this change the strength of the beam? Can you see how a CAD program can be used to rework a poor design?

Wireframe drawings look like wire sculptures. They are see-through stick drawings that show the length, width, and height of an object. Fig. 3-7.

Surface models are more advanced than wireframe models. They are easier to understand and show solids instead of just lines. Fig. 3-8.

Solid models have several advantages over wireframe and surface model drawings. They can be so realistic that they resemble a photograph or the work of a skilled artist. Also, the CAD operator can specify that the object be made of a particular material. The model of an object, such as a beam, can then be tested on the computer to determine important qualities such as weight and strength. Fig. 3-9.

Drawings of newly designed products are used to make *prototypes* (PRO-tow-types), or models. Detailed drawings describe the final product and the assembly line that will be used to manufacture it in quantity.

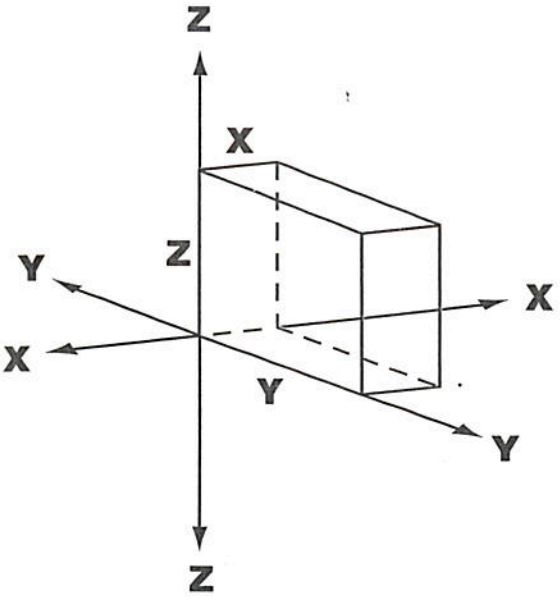


Fig. 3-6 The Z axis.

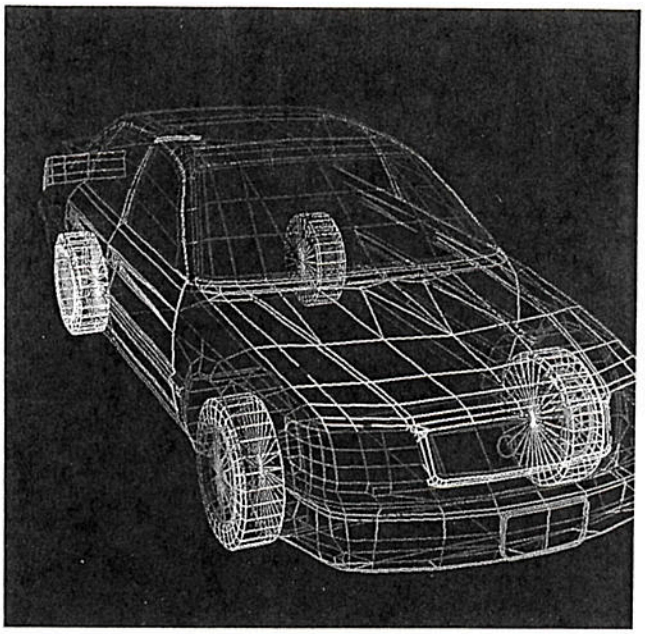


Fig. 3-7 A wireframe drawing presents the surface of the object in a series of interlocking shapes. Design changes can be made quickly on such a drawing.

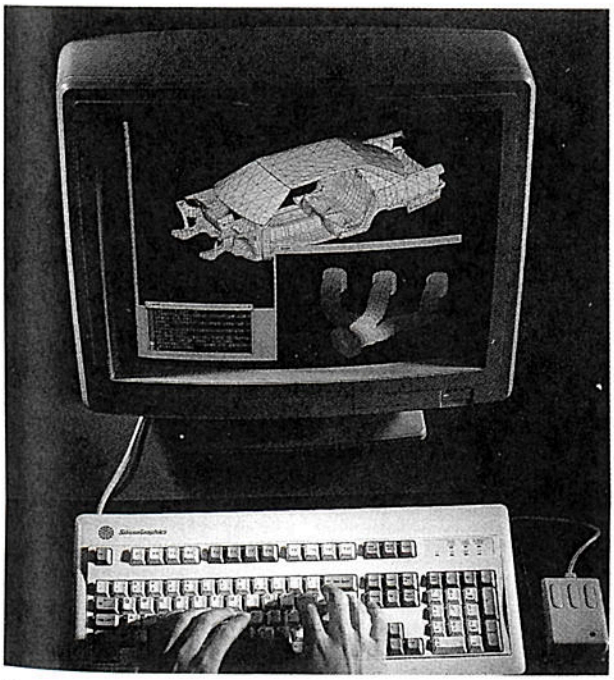


Fig. 3-8 A surface model.

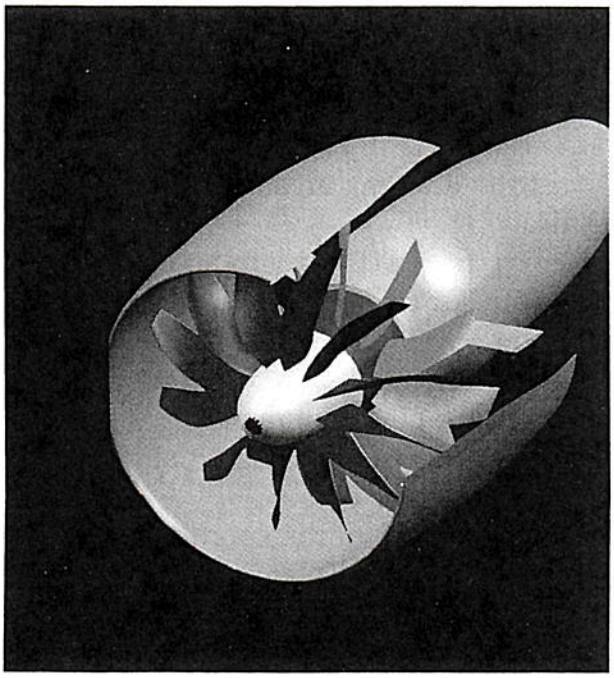


Fig. 3-9 A solid model of a propfan power unit used in aviation.

Explore

Design and Build a Site Plan

Collect Materials and Equipment

calculator
graph paper
computer workstation with AutoCAD Release 12 or later installed

State the Problem

Use CAD to create a site plan.

Develop Alternative Solutions

The house is to be built on a 30' x 35' lot. Use the LINE command to create the outline of the house on the site plan. The house must sit on the lot exactly as shown. Using a calculator and/or graph paper, find the coordinate pairs you will need to create the outline of the house. (Hint: The upper left corner of the house is at coordinates (5,25).) Experiment with different starting points and order of coordinate entry.

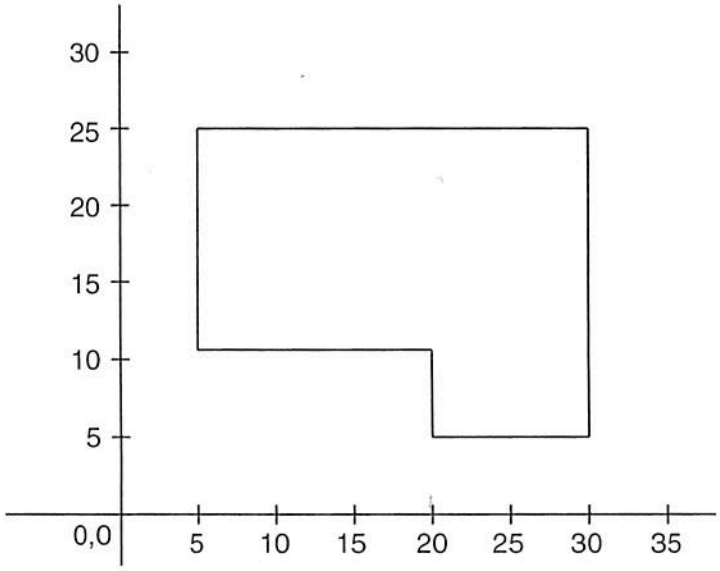
Select the Best Solution

Decide where you will start (with which coordinate pair). In what order will you enter the coordinate pairs?

Implement the Solution

Note: The first three steps make the drawing area large enough to show the entire site plan.

1. Enter the LIMITS command to set the drawing area for this drawing.
2. Press the ENTER key to accept a lower left corner of 0,0.
3. Enter 50,40 to set the upper right corner.
4. Enter the LINE command.
5. Enter the first coordinate pair to start the floor plan.
6. Enter the rest of the coordinates in the order you planned.



Evaluate the Solution

1. Does your site plan look like the one shown? If not, how does it differ?
2. If you had to create another site plan, what might you do differently? Why?

USING A CAD SYSTEM

CAD drafting is done through the use of commands. A **command** directs the software program to perform specific drawing tasks. Although they are not exactly the same, the basic commands used by popular CAD programs are similar.

The most frequently used commands are in the following three categories: drawing commands, editing commands, and utility commands. The commands are entered by using an on-screen menu, a digitizing tablet, a mouse, or a keyboard. Most CAD programs include tutorials that help new users learn and practice the commands.

Drawing Commands

Drawing commands are used to create lines, circles, and other geometric shapes. Each line or shape is called an *object* or *entity*. The commands described below make it possible to draw almost any object and modify the drawing.

The LINE command is used to make lines by connecting points. The points are selected by using the mouse, puck, or keyboard.

The CIRCLE commands create circles. Circles can be drawn by specifying the radius or diameter of the desired circle. Another way to draw a circle is to select several points on the edge of the circle you want. Fig. 3-10.

The ARC command creates arcs. The length and radius can be specified in several different ways.

TEXT commands are used to add labels and notes to drawings.

DIMENSIONING commands calculate the dimensions of objects.

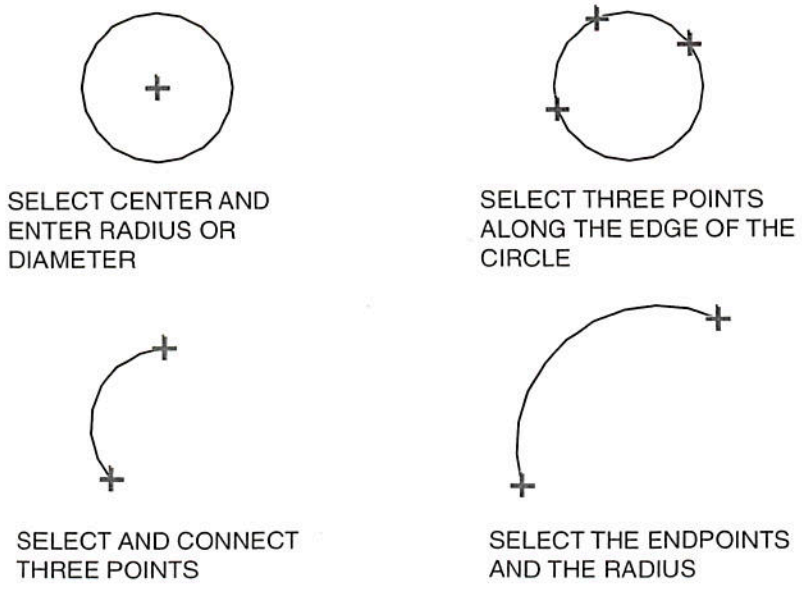


Fig. 3-10 The CIRCLE command.

Explore

Design and Build a Tic-Tac-Toe Board

Collect Materials and Equipment

- calculator
- graph paper
- computer workstation with AutoCAD Release 12 or later installed

State the Problem

Explore CAD commands to create a tic-tac-toe board made up of 2-inch squares. The lower left corner of the board must be placed at coordinates (1,2).

Develop Alternative Solutions

Most CAD programs have more than one way to create objects such as squares and circles. In AutoCAD, you can create a square using the LINE, POLYGON, or RECTANG command. Find out more about each of these commands. (Hint: Refer to the Help pull-down menu in AutoCAD.) What must you know to use each command?

Using a calculator or graph paper, sketch the tic-tac-toe board. Find the coordinate pairs for each of the nine squares.

Select the Best Solution

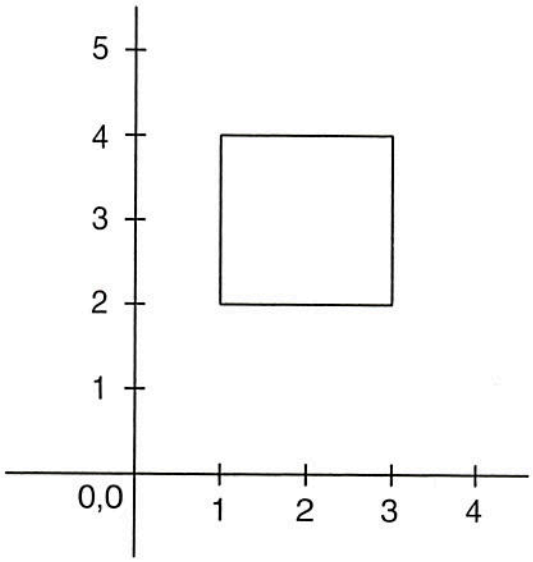
Select the command that seems most efficient in this situation.

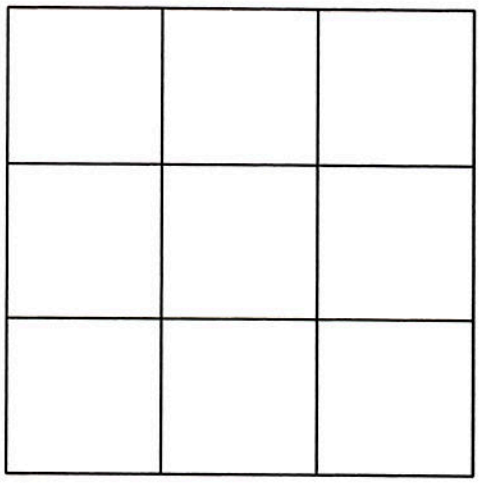
Implement the Solution

The following steps allow you to try each of the three commands. Each set of steps places the first square in its correct location. Follow the steps for all three commands. Decide which command is most efficient. After you have created the first square, use the command you prefer to finish the tic-tac-toe board.

LINE Command

1. Enter the LINE command.
2. Enter these coordinate pairs (in order): (1,2), (3,2), (3,4), (1,4), (1,2). When you enter the coordinates in AutoCAD, do not include the parentheses. Do not type a space after the comma.





POLYGON Command

1. Enter the POLYGON command and specify 4 sides.
2. Enter E to specify the edge of the polygon.
3. Enter coordinate pair (1,2) for the first endpoint and (3,2) for the second endpoint.

RECTANG Command

1. Enter the RECTANG command.
2. Enter the coordinate pair (1,2) for the first corner and (3,4) for the second corner.

After you finish drawing the tic-tac-toe board, play a game of tic-tac-toe with your partner. How will you claim squares? (Hint: You do not have to use Xs and Os. You can use any symbol, such as a diagonal line.)

Evaluate the Solution

1. Which method is the most efficient for drawing the tic-tac-toe board? Is this the method you thought would be best?
2. If you thought another method would work better, explain why. Why did you change your mind?

Editing Commands

Editing commands are used to make changes on drawings.

The ERASE command removes objects from the drawing. It does what an ordinary eraser does, but it does it electronically.

The MOVE command is used to change the location of objects on the drawing.

The COPY command is used to make another copy of an object on the drawing. The copy can be placed in one or more additional locations. The original object remains in place.

The ROTATE command is used to turn an object around a specific point. Fig. 3-11.

The MIRROR command will produce a mirror image of an object. For example, suppose you have drawn the right wing of an airplane. Using the MIRROR command, you can then quickly create the left wing. Fig. 3-11.

Utility Commands

Three frequently used utility commands are ZOOM, PAN, and PLOT.

The ZOOM command works like the lens of a camera. It allows the drafter to reduce or magnify a drawing or part of a drawing as it appears on the monitor. The actual drawing is not changed, but details of it are easier to see.

The PAN command is used with the ZOOM command when the drafter wants to view other parts of the drawing at the same magnification.

The PLOT command is selected to make a hard copy of the drawing.

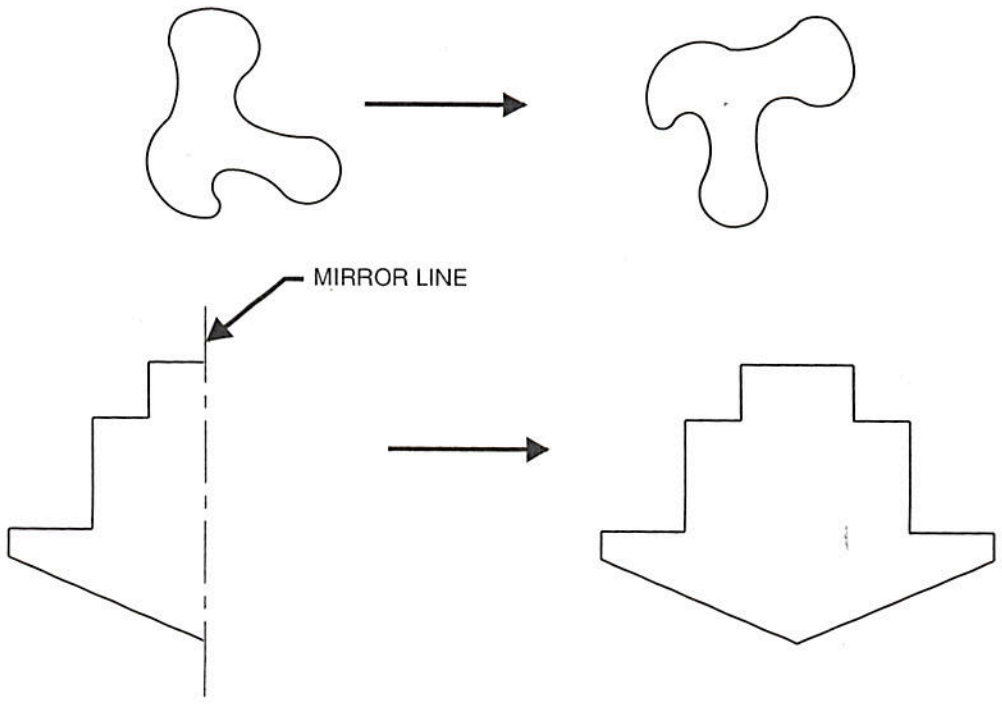


Fig. 3-11 The ROTATE and MIRROR commands.

Linking to COMMUNICATION

Metaphors. Figures of speech make language more interesting and informative. A metaphor is one type of figure of speech. A metaphor compares one thing to another so the reader can more easily understand. In this chapter, the writer uses metaphors to give the reader a better understanding of some ideas. "Drafting is called the language of industry," and "The central processing unit (CPU) is the 'heart' of the computer."

Write a metaphor for each of the following components: monitor, Cartesian coordinate system, printer, and plotter. Be sure to join the two items being compared with the verb "is."

CAD/CAM

CAD/CAM is a process that combines computer-aided drafting and computer-aided manufacturing. In CAD/CAM, output from the computer used to design a product is used to operate the machines that manufacture it. Relatively simple drill presses and complex *computer numerical control* (*CNC*) machines can be controlled in this way.

IMPACTS

CAD has replaced traditional drawing in many industries. Traditional drafters have needed to learn new skills. Fortunately, many have been able to transfer their skills from the drafting table to the computer. Many companies offer the training needed to make this transition.

THE FUTURE

Advanced CAD systems will use *virtual reality*. For example, you will be able to view every room of a new home during the design process. Like some computer games and theme park rides, this imaginary trip will seem real. People working with an architect to design a new home will be able to do a "walk through." They will be able to suggest changes before the plans are complete. Virtual reality also will be used to show the inner workings of complex machines before they are built. Fig. 3-12.

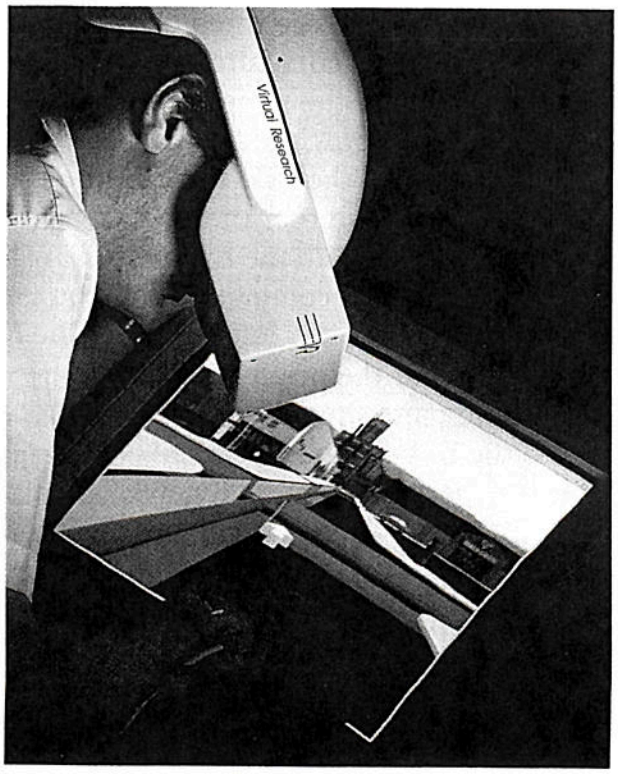


Fig. 3-12 This urban planner is using a virtual reality system. It allows him to assess traffic flow in a redesigned intersection.

Apply What You've Learned

Design and Build Orthographic Projection

Collect Materials and Equipment

calculator
graph paper
computer workstation with AutoCAD Release 12 or later installed

State the Problem

Create a three-view drawing of the step block.

Develop Alternative Solutions

An *orthographic projection* is a drawing that contains several views of a three-dimensional (3D) object. It contains enough two-dimensional (2D) views to describe the object completely.

Study the step block shown in Fig. A. Use a calculator to find the missing dimensions. On graph paper, sketch the three views you need to describe the block completely. Place the top view at the top of the paper. Place the front view below the top view so that their edges align. Then place the side view on the right side of the front view so that their edges align.

Plan ways to create the drawing using CAD. What command or commands will you need? Assume that the lower left corner of the front view is at the origin (0,0). What coordinate pairs should you enter to create the three views? Remember to leave space between the views.

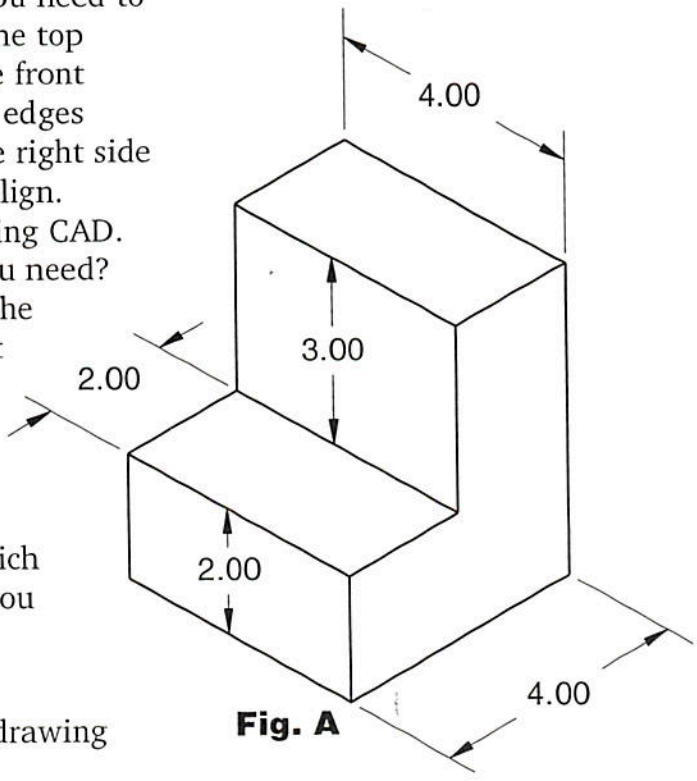


Fig. A

Select the Best Solution

Decide where you will start (with which coordinate pair). In what order will you create the views?

Implement the Solution

Note: The first three steps make the drawing area large enough to show the entire orthographic projection.

1. Enter the LIMITS command to set the drawing area for this drawing.
2. Press the ENTER key to accept a lower left corner of 0,0.

3. Enter 50,40 to set the upper right corner.
4. Enter the LINE command.
5. Enter the first coordinate pair to start the first view you plan to draw.
6. Enter the rest of the coordinates to finish the first view.
7. Using the coordinates you determined on graph paper, create the other two views.
8. Enter DIM at the Command line to enter the Dimensioning mode.
9. Enter HOR (for Horizontal), press ENTER to select a line, and pick the bottom line of the top view.

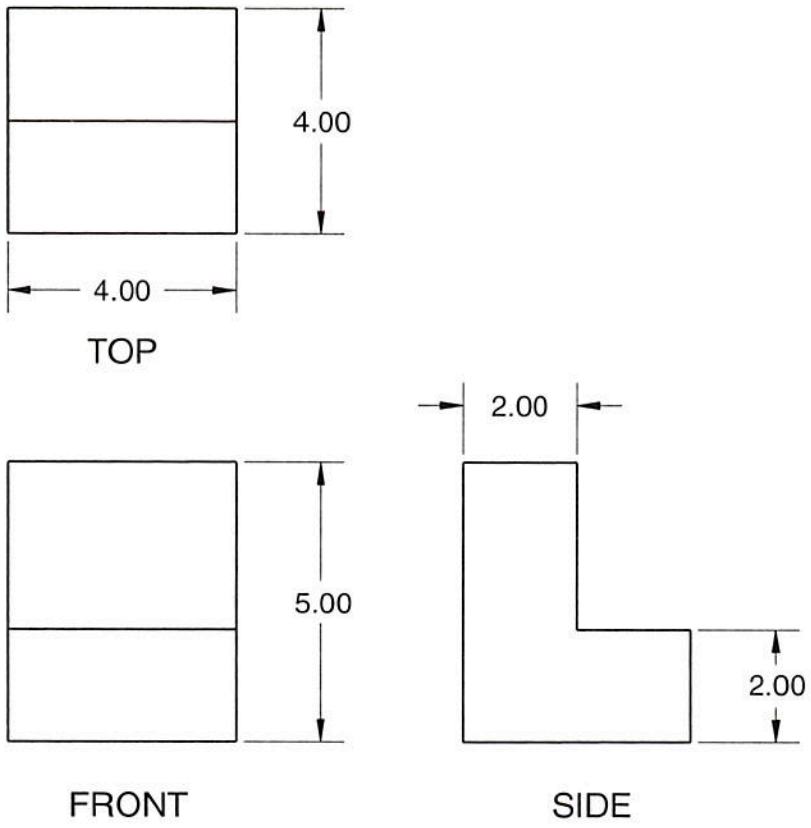


Fig. B

10. Move the cursor away from the line and pick a point to place the dimension. Press the ENTER key to finish the command.
11. Reenter HOR and create the horizontal dimension on the side view.
12. Enter VER (for Vertical), press ENTER to select a line, and pick the right side of the top view.
13. Move the cursor away from the line and pick a point to place the dimension. Press the ENTER key to finish the command.
14. Reenter VER to create the remaining dimensions, as shown in Fig. B.

Evaluate the Solution

1. Is your orthographic projection similar to the one shown?
2. Did the coordinates you chose for the top and side views leave enough space between views?
3. Can you think of an easier way to create the three-view drawing? Explain.

CAREERS IN
Computer-Aided Drafting (CAD)

DRAFTER

Growing manufacturer needs drafter with CAD skills. Duties include making new drawings and revising both CAD and paper drawings that range from simple machine components to detailed assemblies and technical illustrations. Will use standard drafting techniques and devices as well as computer-assisted design/drafting equipment. Send resume to: Dreisson International, 5610 Barberton Avenue, Detroit, MI 68901.

ARCHITECTURAL DRAFTER

Retail design firm seeking drafter with training in CAD systems to draw architectural and structural features of buildings. Architectural experience and knowledge of construction a plus. Entry-level position offering excellent growth opportunities. Salary plus comprehensive benefits. Submit resume to Chase and Brass Architects, Inc., 190 North Union Street, Littleton, CO 76658.

CIVIL DRAFTER

Construction company seeks drafter to prepare and update drawings, site plans and maps used in highway engineering projects. Some field work required for revisions of plans. Experience with CAD required. Excellent salary and benefits. Forward resume to: Allen Construction Company, 3490 Branch Highway, Gainesville, FL 22385.

DESIGN TECHNICIAN

Steel fabricator seeking a disciplined self-starter with experience in a diverse, demanding manufacturing environment. The successful candidate must have drafting skills, CAD experience, knowledge of fabricating and welding. Strong communication skills and computer literacy a must. CNC knowledge a plus. We offer an excellent salary and benefits package. Send resume to: Twinsburg Steel, 1902 Huron Avenue, Toledo, OH.

TECHNICAL ILLUSTRATOR

Electronics manufacturing company has an immediate opening for a technical illustrator. Will lay out and draw illustrations for use in technical manuals dealing with assembly, installation, and operation of equipment. Responsible for preparing drawings from blueprints, designs, mockups and photoprints using drafting and optical equipment. Please submit resume to: Electro Industries, 1800 Ross Street, Allen, PA 56628.

Linking to the WORKPLACE

When selecting a career you should think about your personal interests, your skills, the educational requirements, and the work setting for the job—just to name a few. However, there are other considerations. One area that people focus on is money. How much will the job pay? Choose one of the careers listed above. Pretend that it is your job. Now develop a budget based on your salary. How much will you be able to save? How much will you spend each month on rent, car, food, clothes, and entertainment? Do you think the job you selected will pay enough? Will you need to cut back on spending?

Chapter 3 Review

SUMMARY

- Computer-aided drafting (CAD) is replacing traditional drafting. Compared with traditional drafting, CAD is faster, more accurate, and neater.
- CAD systems require hardware and software. The hardware includes a computer, an input device, and an output device. CAD software allows a drafter to use the computer as a drafting tool.
- The Cartesian coordinate system is based on an imaginary grid with X, Y, and Z axes.
- CAD can be used for two-dimensional and three-dimensional drawings.
- Important kinds of three-dimensional drawings are wireframe drawings, surface models, and solid models.
- Commands direct the software program to perform specific drawing tasks. Frequently used commands include drawing commands, editing commands, and utility commands.

CHECK YOUR FACTS

1. Name three advantages of CAD when compared with traditional drafting.
2. Identify and describe the hardware and software that CAD systems require.
3. What is the difference between 2D and 3D drawings?
4. Identify some uses of CAD in industry.
5. What are the three main categories of CAD commands?

CRITICAL THINKING

1. Describe how CAD can be used in manufacturing and construction.
2. Make a labeled sketch to show the hardware components of a CAD system.
3. Describe the Cartesian coordinate system.
4. Explain two advantages of solid model drawing over other kinds of three-dimensional CAD.
5. Draw a chart that shows the basic drawing commands.