CHAPTER

6

Communicating Solutions

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OBJECTIVES

After studying this chapter, you should be able to:

- Explain the importance of properly communicating design solutions.
- Identify three types of working drawings.
- Describe different drawing classifications.
- Select and use appropriate symbols.
- Identify line types used in drawings.
- Describe dimensioning guidelines.
- Discuss industry guidelines used in communicating design solutions.

THINK LIKE AN
ENGINEER
What methods do engineers use to communicate their problem-solving designs?

Key Terms

assembly drawing
detail drawing
dimensioning
engineering drawing
leader
location dimension
oblique drawing
perspective drawing
schematic drawing
shape dimension
size dimension
visualization
working drawing

Once engineers complete their initial research of designs, they begin to create solutions to solve their problems. You have learned that the solution creation step includes analyzing design solutions and choosing solutions. The final step in creating solutions is to communicate the solution. See **Figure 6-1**. Engineers use different types of drawings to further design their initial brainstorming ideas. In this chapter, different types of engineering drawings used to illustrate design solutions are described. This chapter shows the different types of drawing methods used by engineers. Engineers must select the appropriate drawing approach to ensure their designs are clear to managers, fellow design team members, and customers.

"Design is a solution to a problem; art is a question to a problem."

—Jon Maeda

Engineering Drawings

Engineers use drawings to further develop and communicate their designs. ***Engineering drawings*** are created to communicate products that will be manufactured. As you will see in future chapters, there are different engineering disciplines that develop different types of products, but all engineers rely on engineering drawings to move their designs into production.

Working Drawings

Engineers develop working drawings. ***Working drawings*** are engineering drawings that are the most complete drawings produced. Unlike rough and detailed sketches, discussed in Chapters 4 and 5, working drawings are extremely detailed and must be developed following strict standards. Most engineers follow the standards set forth by the American National Standards Institute (ANSI) to develop working drawings. By following specific guidelines, engineers can ensure their designs are understood by other engineers and manufacturers of their designs. Depending on the specific engineering discipline, the engineer uses a combination of three specific types of working drawings: detail drawings, assembly drawings, and schematic drawings.

Detail Drawings

Engineers use ***detail drawings*** to show the exact shape and size of an object. The drawings show multiple views of the object to give an overall image of the object. Engineers select the views that provide the most detail of their designs.

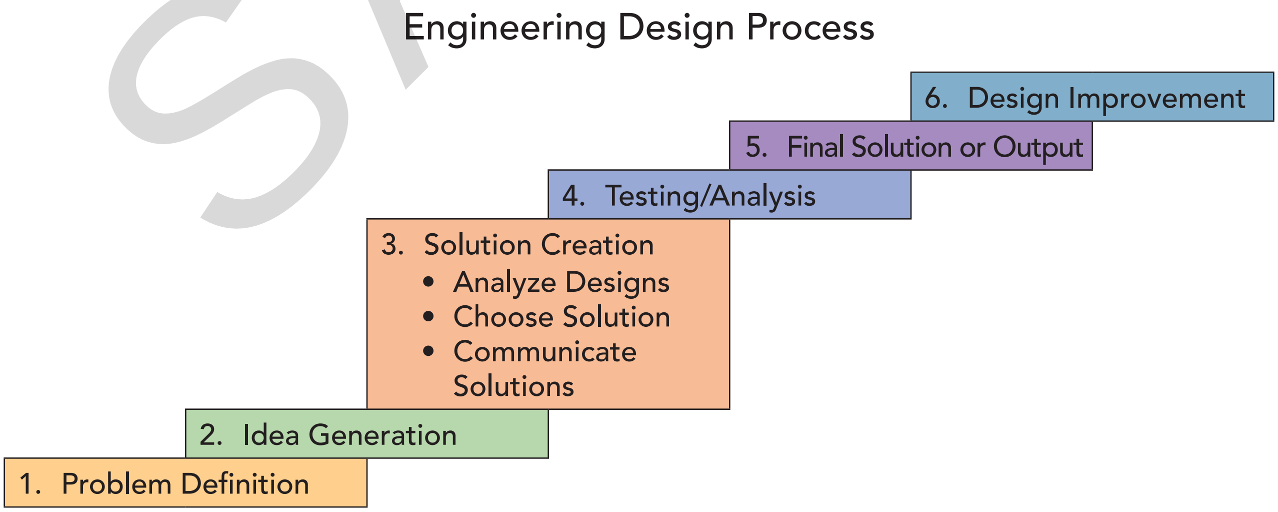

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Figure 6-1.
Following analyzing and choosing design solutions, communicating solutions is the final step in solution creation.

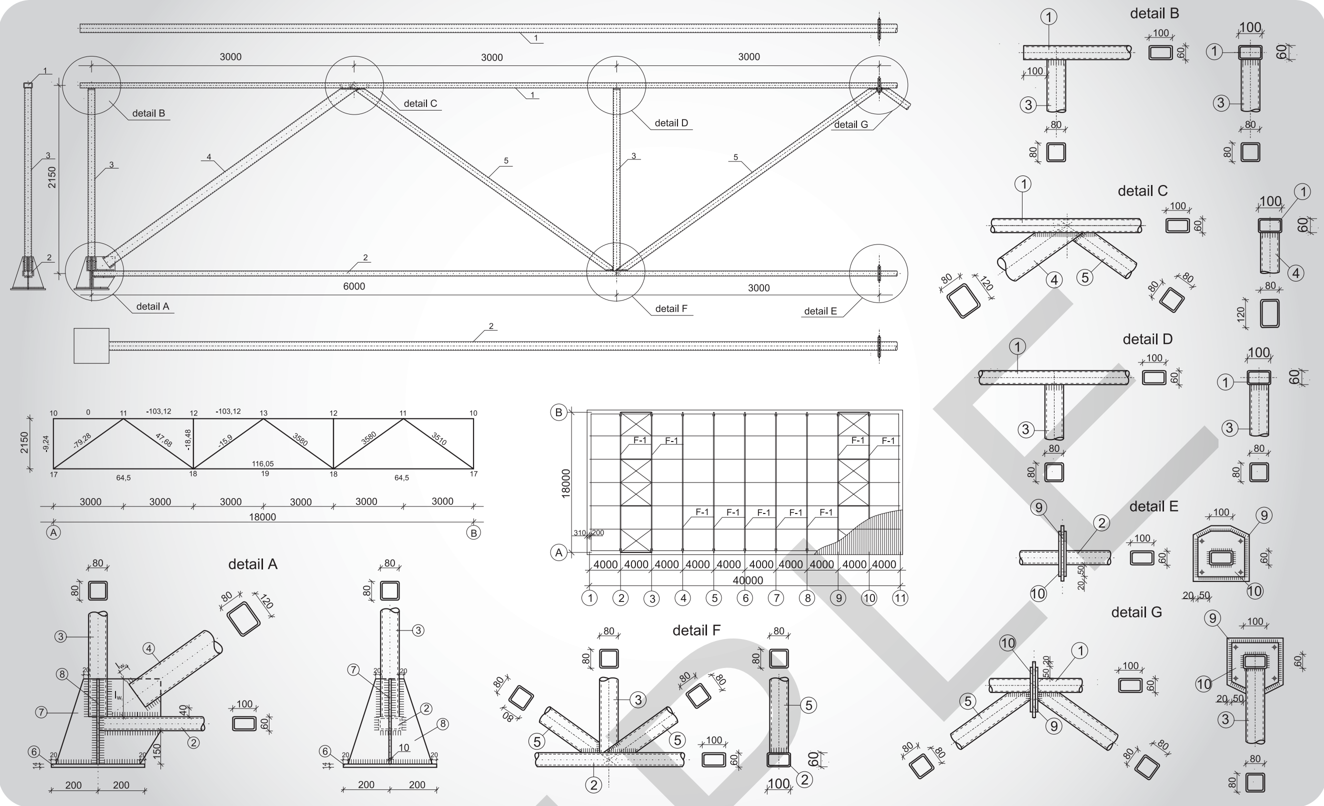

Figure 6-2. Artulina/Shutterstock.com
Detail drawings include dimensions and notes to help engineers and manufacturers better understand the design.
What are some important pieces of information communicated in this drawing?

Detail drawings provide enough information to produce the product. This information varies between products. Detail drawings include dimensions for all parts of the product to show the overall size and shape, along with detailed features of the product. Detail drawings often include notes to better describe the object to engineers and manufacturers. See **Figure 6-2**.

Assembly Drawings

Assembly drawings show how different parts fit together to create the entire object. Also known as *exploded view drawings*, assembly drawings show the relationships among different objects. Engineers use these drawings to simplify their designs and allow others to visualize how the different parts work together. You have seen assembly drawings when you put together a piece of furniture or work on a car. These drawings provide a guide for assembly and disassembly of a product. See **Figure 6-3**. Assembly drawings are drawn in three dimensions but do not show the sizes, or dimensions, of the components. If dimensions are needed for production, manufacturers look at the detail drawings previously discussed.

Figure 6-3. iurii/Shutterstock.com
This computer-generated assembly drawing shows how the product fits together.

Schematic Drawings

Engineers use schematic drawings to show an entire system. ***Schematic drawings*** are used to show how different parts are connected together to form a system. Schematic drawings are most commonly used for plumbing systems, electrical circuits, and production lines. The purpose of a schematic drawing is not to communicate size or shape of an object, but to show how parts of a system work together. Dimensions are not used on a schematic drawing.

For example, electrical schematic drawings show the flow of electricity between different parts of the circuit, and plumbing schematic drawings show the way water flows through all of the different components of a water system. These drawings are intended to show the relationship between all the components in the system. They are often helpful in diagnosing a system problem because they describe the direction of flow and purpose of each object in the system.

The use of symbols is critical to the creation of schematic drawings. See **Figure 6-4**. Engineers follow the ANSI system of symbols. The engineer uses ANSI symbols for each part of the system and lines to connect each part of the system. The lines are used to represent the path. For example, on an electrical circuit, the lines stand for wire, and in a plumbing system, the lines represent the pipe through which the water travels. See **Figure 6-5**.

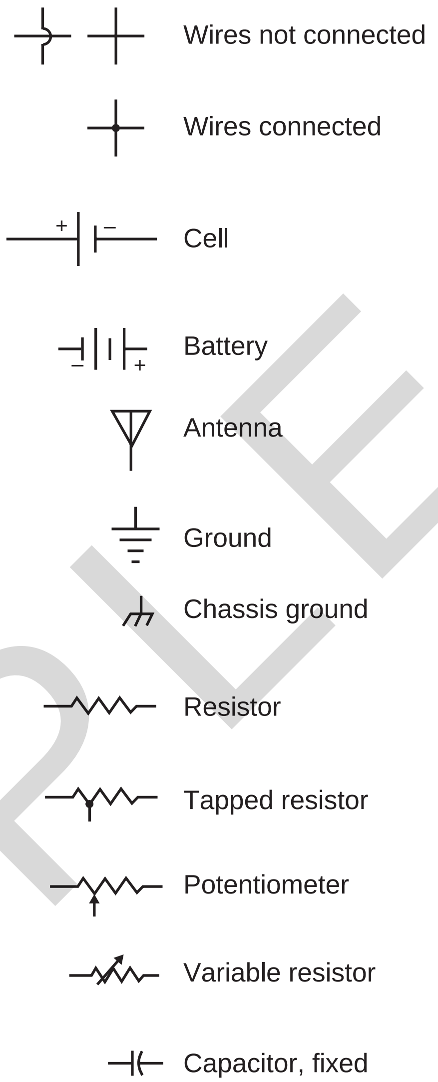

Figure 6-4. *Goodheart-Willcox Publisher*
Standard symbols are used to make schematic drawings easier to draw and understand.

Drawing Classifications

As previously described, engineers use various working drawings to show how a part is put together or to show the specific parts of a design. These drawings comprise two types of drawings: orthographic drawings and pictorial drawings.

Orthographic Drawings

Orthographic drawings use multiple views to describe the size and shape of an object. Because these drawings show many different views, they are often referred to as *multiview drawings*. Any three-dimensional object has six sides that can be illustrated. Engineers can use any combination of these six sides to illustrate an object. Engineers must select the best views to communicate their designs. Many times, engineers will use 3D modeling software (discussed in Chapter 7) to create a model and then create orthographic drawings from their overall design to communicate their solution to production staff.

Orthographic drawings can be detail drawings when they contain all the appropriate information. However, not all orthographic drawings are detail drawings. Orthographic drawings are often developed as a rough sketch used to show the overall view of the object. They may not include all the information from a detail sketch.

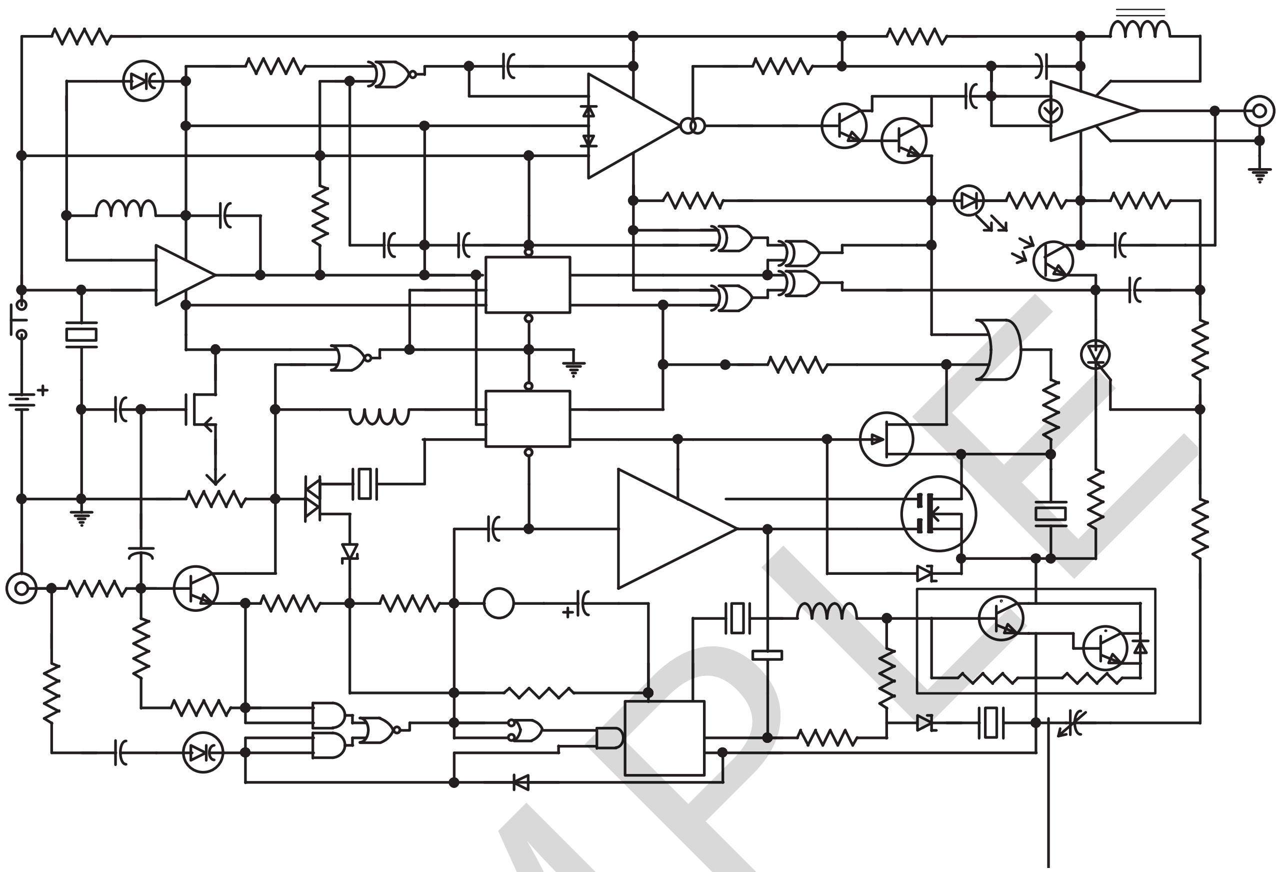

Figure 6-5.
ermess/Shutterstock.com
Schematic drawings are used to communicate electrical circuits or plumbing systems.

Orthographic drawings are created using orthographic projection. Orthographic projection can be confusing to understand. The key to understanding orthographic projection is the ability to visualize the product. ***Visualization*** is the ability to mentally see a representation of a product for which there is no physical object. Engineers must have the ability to visualize objects. Engineers use orthographic projection to describe their visualization of a solution.

"Design is thinking made visual."
—Saul Bass

Orthographic projection can have up to six different sides, as in the case with rectangles. See **Figure 6-6**. Every rectangular object has four sides, a top, and a bottom. Each side becomes a different view. Orthographic drawings illustrate specific sides of an object. For example, when you look at a car from the front, you see the front bumper, headlights, windshield, side mirrors, and many other details. How does the view

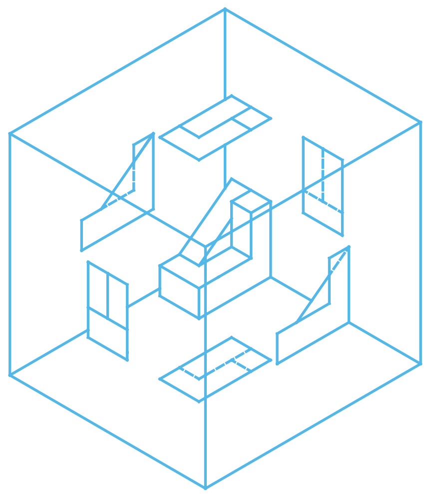

Figure 6-6.
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The views of the object are projected onto the sides of a box.

History

History of Drafting

A drafter is someone who draws documents for official purposes. Drafters are among the oldest documented professions. Drafting began with prehistoric humans drawing images on the walls of their caves to communicate their ideas and representations of the world around them. The first known cave paintings, found in Aurignac, France, were drawn thousands of years ago. Drafters have used many different tools over the years such as rocks, sticks, pencils, T-squares, compasses, and now, CAD software. While the technologies have drastically changed, the basic principle has remained the same. Engineers and drafters communicate their design ideas with others to produce solutions to the problems they encounter. See **Figure A**.

Figure A. DC Studio/Shutterstock.com

change when you look at the car from the side? On the side of the car, you see the front fender, driver side door, rear passenger door, rear fender, and small door that covers the gas cap. When you move to the rear of the car, what do you see? You see the rear bumper, taillights, back end of the trunk, rear windshield, and side mirrors sticking out from the sides of the car. If you crawl underneath a car, what do you see? You see the many different components that make the automobile move. You will see suspension systems, the engine, transmission, exhaust system, and many other objects. If you look at the car while standing above it, you see the top of the hood, passenger cabin, trunk, and side mirrors sticking out from the sides of the car.

To accurately describe the car, you need information from all of these views. This information includes the height of the car from the side, front, or rear; the width of the car from the top, front, or rear; and the overall length of the car from the top, bottom, or side.

While a car is a complex machine, basic shapes also need information from all the sides to determine the overall size of the object and features on each side. Depending on the object, engineers may use any number of views to communicate their designs. Most commonly, engineers select a one-view drawing, two-view drawing, or three-view drawing.

One-View Drawings

One-view drawings are used to show flat pieces. Usually, these flat pieces have a standard or predetermined thickness. Solutions using materials such as hardboard or sheet metal are often displayed using a one-view drawing because all of the details of the object are usually present on one side of the object. The top view is most commonly illustrated in one-view drawings. See **Figure 6-7**.

Engineers design many projects that use one-view drawings. When engineers create flat objects, such as gaskets, flat plates, or sheet metal parts, they use one-view drawings. Manufacturing engineers also commonly use one-view drawings to communicate the details of a sheet metal stamp for the production of a specific part.

One-View Drawing

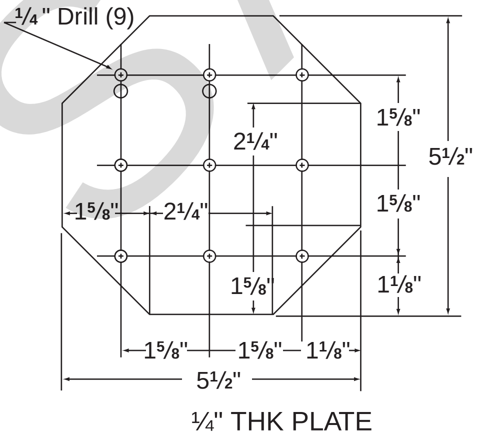

Figure 6-7. *Goodheart-Willcox Publisher*
This one-view drawing shows a flat object. ***What objects do you think could be shown appropriately using a one-view drawing?***

Two-View Drawings

Engineers use two-view drawings to show cylindrical objects and objects with a round shape. Cylindrical objects are usually shown in two-view drawings and include one view that is a circle and one view with the details from the side of an object. To use a two-view drawing, the object must have consistent details around the shape so it appears similar on all sides. Engineers can use two-view drawings to show the front, sides, top, or bottom of an object. See **Figure 6-8**.

Two-View Drawing

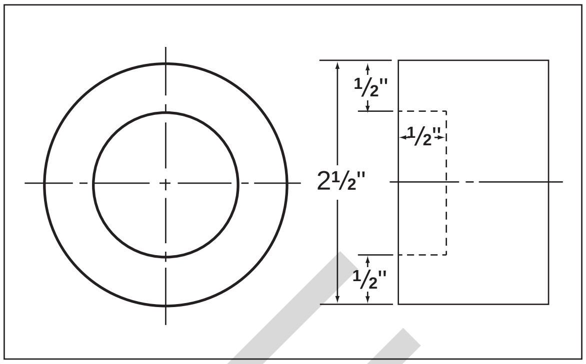

Figure 6-8. *Goodheart-Willcox Publisher*
This two-view drawing shows a round object. ***In what instances could a two-view drawing be used to represent objects that are not round?***

Cylinders for engines are drawn using a two-view drawing. The top view of an engine cylinder will highlight the overall diameter of the cylinder and the side view shows the placement, size, and arrangement of the rings.

Three-View Drawings

Three-view drawings are most commonly used for rectangular objects. Traditionally, three-view drawings show the front, top, and side views of an object. Engineers use the front view to show the height of an object, the top view to show the thickness of the object, and the side view to show the width of the object. See **Figure 6-9**.

Complex designs require a three-view orthographic drawing. Brackets used to attach materials to a wall are communicated using a three-view drawing because of the different features on each side of the design. Also, products made from solid materials, such as a cylinder head on an engine, will feature three views. Structural engineers use three-view drawings to show the details and specifications for a support beam with holes to connect to another part of the structure.

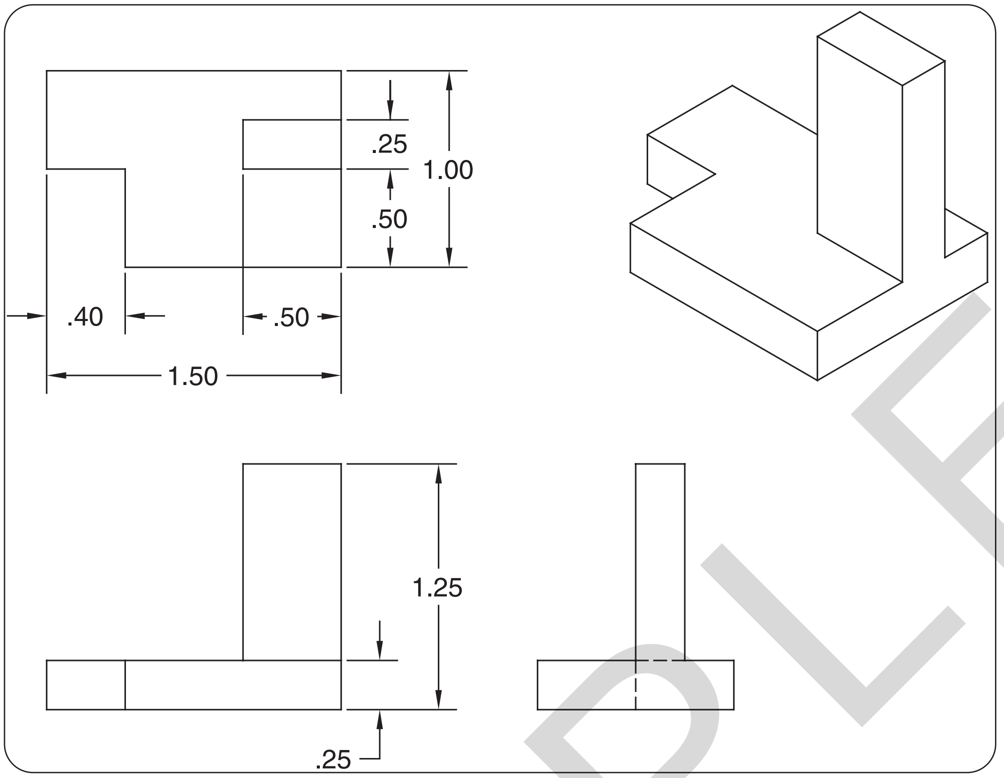

Figure 6-9.
A three-view drawing of an object.

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Did You Know?

Orthographic projection drawing techniques were created during the Industrial Revolution (1760–1840) to accurately communicate design for manufacturing production.

Pictorial Drawings

Pictorial drawings show the object as it would appear to a person looking directly at the object. Pictorial drawings are like pictures. They are commonly used to communicate designs to people who do not use or understand orthographic drawings.

Math

Triangles

The triangle theorem states that all interior angles of a triangle add up to 180°. We use the triangle theorem to identify the missing angles in a triangle using an algebraic equation. Look at the triangle in **Figure A**. We are given the angles for A and B, but we must find the interior angle for C.

$\angle A + \angle B + \angle C = 180°$
$30° + 90° + x = 180°$
$120° + x = 180°$
$x = 180° - 120°$
$x = 60°$

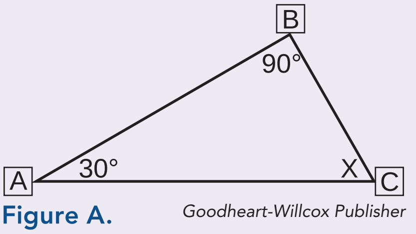

Figure A.

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For each of the problems below, two angles of a triangle are given. Use the algebraic equation and the triangle theorem to find the missing third angle.

1. 90°, 45°
2. 50°, 60°
3. 35°, 65°
4. 53°, 67°
5. 22°, 86°
6. 89°, 22°

Figure 6-10. Ala Alkhouskaya/Shutterstock.com
Pictorial drawings are like pictures and are used to communicate designs to customers or fellow designers.

Engineers use pictorial drawings to communicate designs to their customers or fellow designers. Pictorial drawings appear three-dimensional so they are easy to understand, and they give an overall view of the design. See **Figure 6-10**. The three types of pictorial drawings most commonly used by engineers are isometric drawings, oblique drawings, and perspective drawings.

Isometric Drawings

Isometric drawings are the most commonly used type of pictorial drawing. Isometric drawings use angles equal to each other and are always drawn using the same standard angles. The lines at the bottom of the object are always 30° from the baseline, with the opposite corner 150° from the baseline. See **Figure 6-11**.

All lines in isometric drawings are drawn to scale, which means all the lines are drawn at the same proportion of the object. In brainstorming, a sketch size is not a critical concern, but in final isometric drawings, dimensions must be accurate.

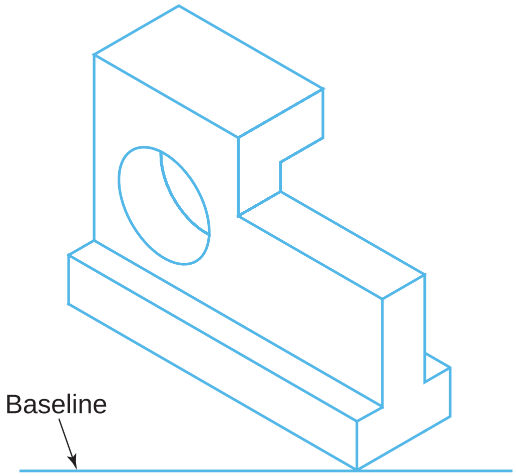

Figure 6-11. Goodheart-Willcox Publisher
Isometric drawings are created so the horizontal lines are 30° from the baseline.

Oblique Drawings

Engineers use oblique drawings to highlight one side of an object. ***Oblique drawings***, like isometric drawings, are drawn in three dimensions, but instead of using a determined angle at the front of the image, the drawing features one side of the object as the front image. Oblique drawings are commonly used when the details of one side of the object are more important than those of the other sides. Engineers do not use these drawings as often as they use isometric drawings.

Engineers begin by drawing the front view at full size or to an appropriate scale, as it would be drawn in an orthographic drawing. Once the front view is completed, the engineer draws lines back at angles to provide depth to the object. The most common angles used for oblique drawings are 30° and 45°. Receding lines may be drawn to scale. See **Figure 6-12**.

Engineers commonly use oblique drawings for objects that feature a great amount of detail in the front view. For example, a new television design is best shown using an oblique drawing. Engineers may want to communicate the look of the front of a computer to a customer who is not concerned with the appearance of the sides of the unit. Also, engineers may use an oblique drawing to show the details on the front of a new refrigerator design.

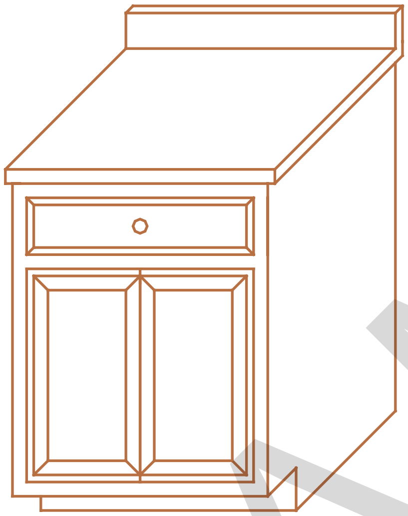

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Figure 6-12.
Objects that are most detailed in the front view are often drawn as oblique drawings.

Perspective Drawings

Perspective drawings are used to show an object from a specific point of view. Perspective drawings simulate what the eye sees if looking at the object. The most unique part of a perspective drawing is the use of a vanishing point. A vanishing point is a spot at which receding lines converge. Engineers may choose to illustrate their designs using a one-point perspective, two-point perspective, or three-point perspective.

A one-point perspective drawing uses one vanishing point. One-point drawings look similar to oblique drawings because all of the angles are going to one location from the front image. One-point perspective drawings are different from oblique drawings because the side lines go to a point instead of at a set angle from the front image.

Two-point perspective drawings are developed with an angle at the front of the drawing, like an isometric drawing, but instead of being drawn at set angles, the lines of both sides are drawn to a point. See **Figure 6-13**.

Three-point perspective drawings use three vanishing points: one located on each side and

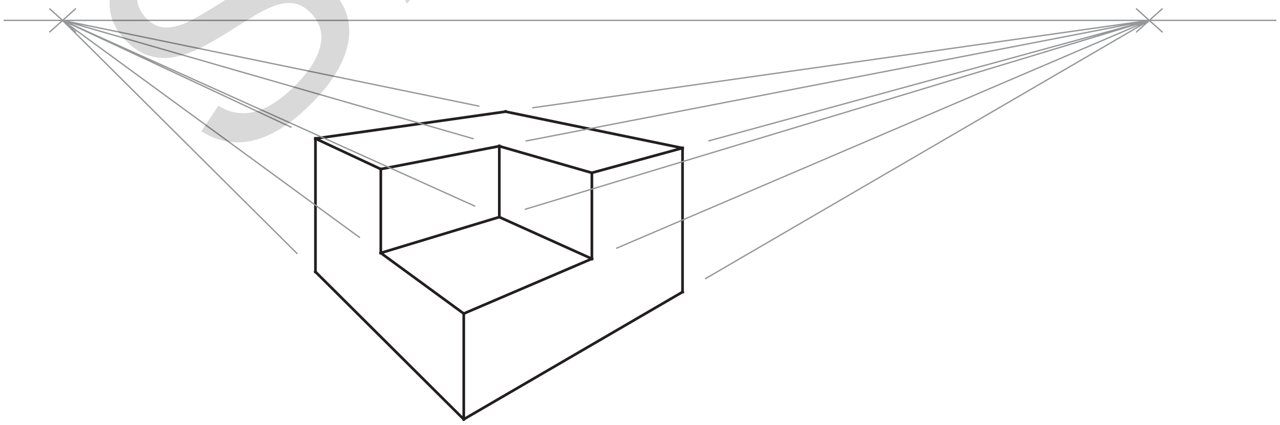

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Figure 6-13.
This is an example of a two-point perspective drawing.

Design

Drafting Drawings

Engineers create multiple drawings and have to provide information about many different factors to communicate the details of their design. Engineers provide detailed information using the skills explored in this chapter, starting with 2D drawings and moving all the way through the development of detailed section views and working drawings. To practice these skills, complete the following activity.

Design a shelving system that can hold a video game console, the controllers, and at least 10 games. Your design should include:

- Multiple line types.
- A 2D single-view drawing.
- A multiview drawing with orthographic projection.
- Dimensions using ANSI standards.
- A pictorial view.
- A section view drawing.
- The use of multiple hex head bolts as fasteners including standard, square, and acme threads.

You may work in groups to complete this activity.

one located above the object. Three-point perspective drawings are not nearly as common as one- and two-point perspectives, but they are used by structural engineers to show how a building will look from the ground looking up at the building.

> *"Styles come and go. Good design is a language, not a style."*
>
> —Massimo Vignelli

Drawing Guidelines

In the previous sections of this chapter, we discussed the many different types of drawings engineers use to communicate their designs. Engineers must also follow standard methods and rules when creating these drawings. Following the standards and methods ensures their solutions are properly communicated to other members of the design team and the production staff who will produce the final product. Using proper techniques allows engineers from across the globe to interpret the drawings.

Symbols

Symbols are used to represent different entities in a drawing. As shown earlier in this chapter, symbols are regularly used in schematic drawings to represent different parts of an electronic or hydraulic circuit. In schematic drawings, the symbols represent a specific component of the circuit. Symbols are also used to inform engineers and production staff about different criteria required to produce a solution.

Symbols are used in engineering drawings to show the properties of a specific object. In technical drawings, engineers use symbols to illustrate the diameter of a specific part or to illustrate the center of an object. Each engineering discipline, discussed in later chapters, uses specific symbols to help communicate designs. Along with discipline-specific symbols, standard symbols are used across many different engineering disciplines. This section describes standard symbols used to create technical drawings across different engineering disciplines.

Many organizations develop symbols to use throughout the different engineering disciplines, but two major groups are ANSI and the International Organization for Standardization (ISO). The guidelines developed by ANSI and ISO are accepted by engineers worldwide.

Some ANSI symbols associated with schematic drawings were shown earlier in the chapter, but ANSI has developed many other symbols for other fields such as mechanical engineering and structural engineering. ISO provides symbols we use every day, such as safety symbols, **Figure 6-14**.

Line Types

When you view an engineering drawing, many different types of lines are visible. Engineers

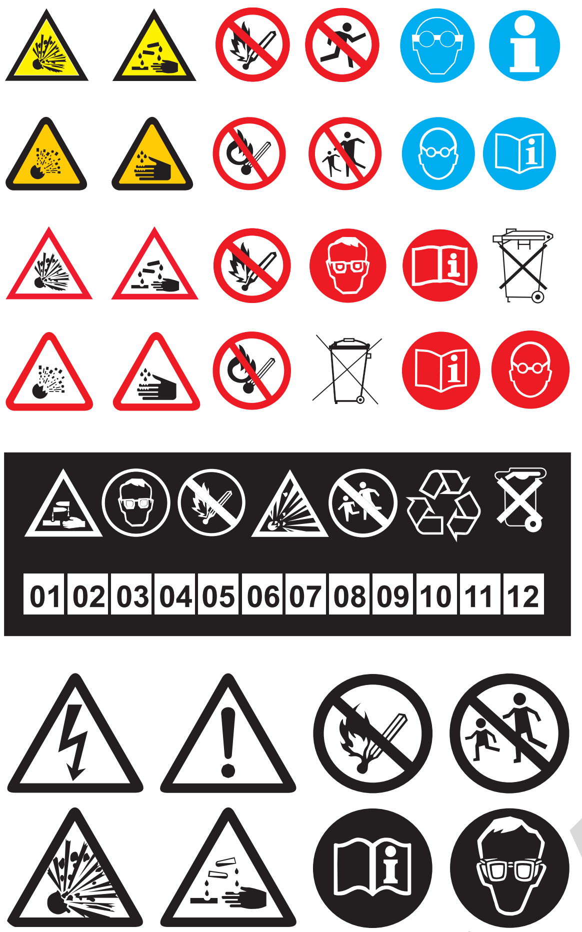

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Figure 6-14.
These safety symbols are used to help people understand various warnings. ***What are some symbols you see in your home or school?***

also use different line types in drawings to highlight different parts of a design and to show features that may not appear if you were to look at a 3D model of the object. Each line type has its own characteristics, which are universally understood by engineers and manufacturers producing the objects. See **Figure 6-15.** The five primary line types are construction lines, object lines, hidden lines, centerlines, and border lines.

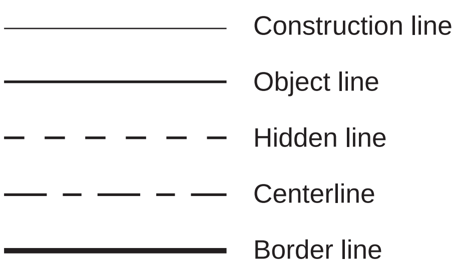

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Figure 6-15.
These are the five primary lines used in a drawing.

Construction lines are lightly drawn lines used to lay out the drawing. They are not part of the object itself. They are merely used as reference points to help connect different pieces of the drawing. Construction lines are usually removed from the final drawing, and with the use of computer-aided drafting (CAD) software, they do not appear on the final print.

Object lines are heavy, dark lines used to show the edges of the object in the drawing. Object lines are the actual outline of the object and are the visible edges if you are viewing the 3D model of the object.

Hidden lines are drawn with short dashes. Hidden lines are used to show parts of the drawing that are hidden from sight in the view that is drawn. Hidden lines may be used to show details that are cut out of the bottom of an object and lines that may be visible when you look at the object from another view.

Centerlines are drawn using alternating short and long dashes. Centerlines are used to show the center point of an object. Engineers need to show the center points of many objects including circles, arcs, and ellipses.

Border lines are the thickest and darkest lines in a drawing. Border lines are used to create a border around the edges of the paper.

Scale

Drawings may be drawn at full scale, which means all lines on the paper are identical to the size of the actual product. Full scale means 1″ = 1″ (or 1:1). Full scale should be used if the object will fit on the paper; if not, you may use a different scale.

Using a different scale typically reduces the lines of the drawing so the object fits on the paper but remains proportionally correct. You can draw the product so that every 1/2″ on the paper equals 1″ on the actual product. This is called 1/2″ = 1″ scale (or 1:2). Some common scales include 1/2″ = 1′ and 3/8″ = 1′. You may use other scales as well if your object will not fit onto the paper or if it will be too small to see on the paper. See **Figure 6-16**. Scale is selected depending on the size of the object and the amount of room you have on the paper to illustrate the drawing.

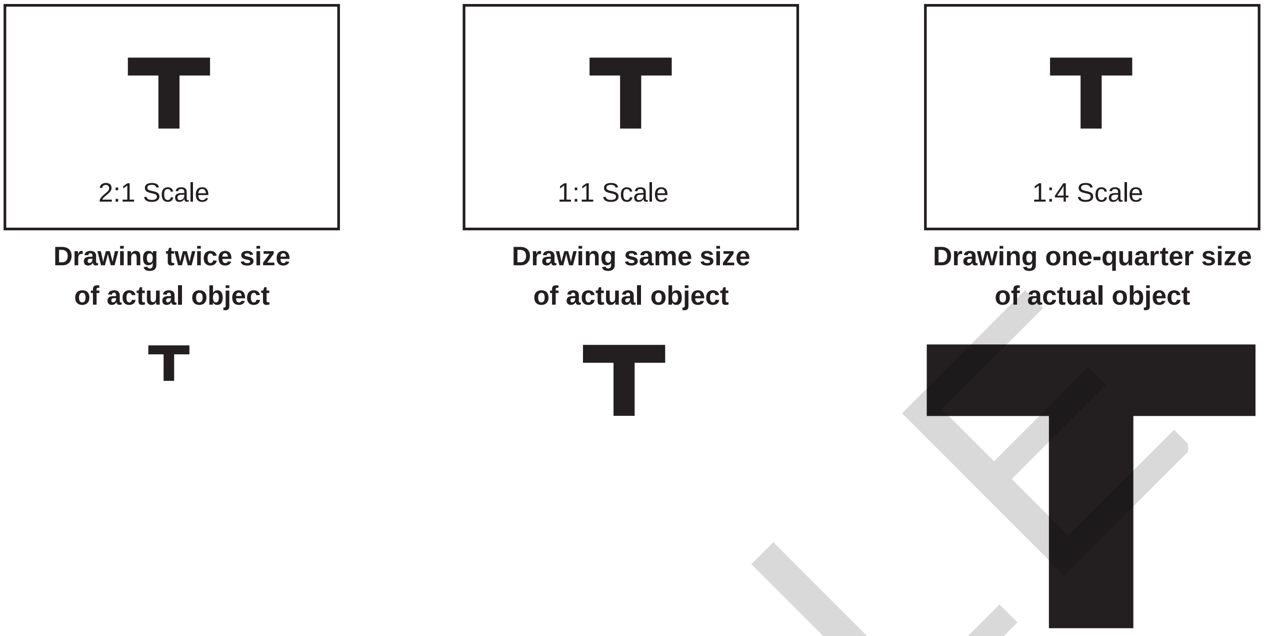

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Figure 6-16.
Different scales are used to enlarge or reduce a drawing. ***Have you ever used a scale to build something, such as a model?***

Dimensions

Engineers use drawings to show the shape of their design and use different types of lines to show features of their drawings, but they must also share the size of the drawing. ***Dimensioning*** is a process used to describe the size of the object as well as the location of different features of the design. When dimensioning, engineers use two different types of lines: extension lines and dimension lines. Extension lines are drawn from very near the edge of the object to outside the view. Extension lines can also be drawn from a feature in a drawing. Dimension lines are drawn between extension lines and have an arrow at each end of the line. The middle of the dimension line is where an engineer provides the actual measurement, or dimension text, for the object, **Figure 6-17**.

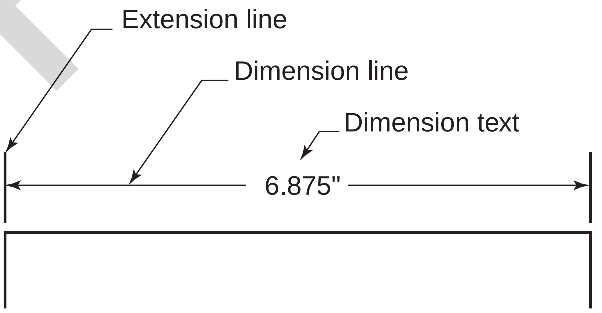

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Figure 6-17.
This example shows an extension line, dimension line, and dimension text.

There are three types of dimensions in a drawing: size dimensions, location dimensions, and shape dimensions. Engineers use ***size dimensions*** to describe the length, width, and depth of an object. ***Location dimensions*** are used to show the distance between two different features. Location dimensions can be used to show the distance between two endpoints, the center of two circles, or any other feature in the drawing. ***Shape dimensions*** are used to provide detailed information about the shape of features. Usually, shape dimensions are used to show angles between different features of the object.

Much like the standard use of symbols in drawings, there are certain rules engineers follow when they provide dimensions. These include the following rules:

- Dimensions should not be placed inside an object.
- Dimensions should be placed between views, rather than along the outside of an object.

Science

States of Matter

Matter can exist in various states. The most common states of matter are solid, liquid, gas, and plasma.

Solid matter is not flexible in its shape, size, or volume. The particles that make up a solid hold more tightly to one another than particles of other states of matter.

Liquids have flexible shape. A liquid's particles are not woven together as tightly as those in a solid, resulting in flexibility. Any given amount of liquid remains the same no matter what type of container it is put into. Liquid will conform to the shape of its container.

Gas particles do not hold together, making it a free-form state of matter. It is more flexible than liquid because it can spread to the limits of its container, rather than just taking its shape. The volume of gas is not fixed. It spreads throughout a container, so its volume matches that of the container.

The qualities of the plasma state make it similar to the gaseous state. Plasma expands to fill the space in which it is contained. However, plasma particles are electrically charged. Plasma can be found in plasma televisions.

Matter can also change states. For example, water is a liquid. However, it can be frozen into a solid state, or it can be heated into steam, or a gaseous state.

- Dimensions should be placed on the view best showing the measurement. Engineers must decide which view best describes the object.
- The location and size of all circles and arcs must be shown.
- All circles and arcs must be dimensioned in a drawing.

To show the size of a circle or arc, engineers use a leader. A ***leader*** is a line with an arrow on the end pointing to the feature. Circles are identified by using diameter for a size dimension, and arcs and other incomplete circles use radius as a size dimension. See **Figure 6-18**.

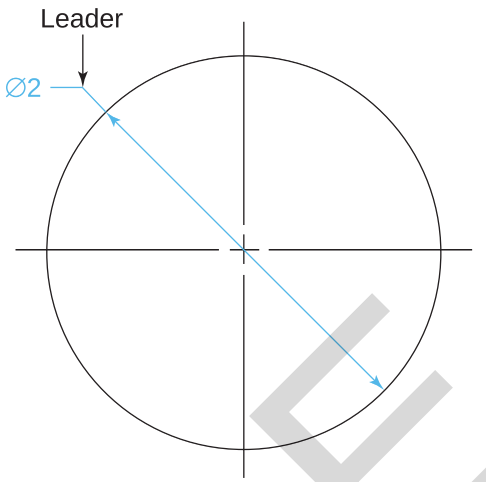

Figure 6-18. *Goodheart-Willcox Publisher*
This example shows the leader, which points to both the object and information about the object. ***If you were drawing an object you chose from your backpack, what information would you indicate using the leader?***

Did You Know?

Complex technical drawings have been used for hundreds of years. During the Renaissance, Leonardo da Vinci created many complex drawings to improve his art.

Industry Guidelines

Engineering drawings follow the standard guidelines provided in this chapter, but it is important to note that there are discipline-specific drawing guidelines. Biological engineers use different types of drawings than mechanical engineers, although many of the basic principles stay the same. Companies and organizations may also have their own procedures and guidelines for drawings.

The guidelines provide the specific procedures, methods, and organization of the engineering design process used by a company's engineers.

Company guidelines typically cover the following criteria:

- **Drawing elements.** There are specific guidelines for the size and format of each drawing. Included in the criteria is the proper size of paper and location of title information for the drawing.

Going Green

Paper Recycling

While the process and guidelines have remained similar, the tools engineers use have drastically changed during the last 30 years, from strictly pencil, paper, and drawing tools to CAD software. With this advancement in computer design, some drawings may not be printed until they are ready to be produced. This has reduced the amount of paper copies used, but engineers and production staff still use paper copies to display for clients, take to field visits, and other uses. Using less paper is good for the environment.

Did you know that in past few years almost 66% of all paper used in the United States was reclaimed and recycled? Paper is made from cellulose, which is fiber found in trees. Engineers developed a method to take used paper, shred it, and mix it with water to create pulp. This pulp is then refined and turned into slush. The slush is then mixed with different chemicals, such as dyes and other additives, and the water is drained. The pulp is then ready to be processed. The pulp is pressed between rollers to remove any moisture and then pressed onto rolls to be used in many different paper products.

- **Nomenclature.** Nomenclature is the proper way to label objects in the drawings. Included in this label are specific abbreviations to use, the proper ways to title different objects, and the requirements for listing materials for each component.
- **Drafting practices.** Drafting practices are general guidelines. Companies develop specific guidelines for different use of line types, lettering, and the use of scale. Also included are specific guidelines for where the object is located on the page of paper.
- **Types of drawings.** The guidelines provide a list of appropriate drawings created by engineers. Listed are detail drawings, assembly drawings, schematic drawings, and many other content-specific drawing types.
- **Drawing revisions.** Also included are detailed descriptions of how to make revisions to drawings. As discussed in this text, engineers often make changes to drawings, and organizations outline specific procedures used to make sure changes are documented during the process.
- **Design references, standards, and specifications.** Guidelines outline the dimensioning processes, types of units used, and the types of standards, specifications, and symbols used for all company or organization design drawings.

At the end of the manual are guidelines for engineering design drawings. Most guidelines include information about accurate dimensioning and methods of reporting information such as size, materials, and part locations.

The attention to detail when reporting information accurately is critical to ensure designs are properly modeled, tested, and created.

Summary

- The communication of solutions is important to make the design clear to everyone.
- Working drawings are the most complete drawings produced. They include detail drawings, assembly drawings, and schematic drawings.
- Two types of drawings classifications are orthographic and pictorial. Orthographic drawings can be one-view, two-view, or three-view drawings. Pictorial drawings include isometric, oblique, and perspective drawings.
- Standard symbols are used throughout various engineering disciplines to represent different entities in a drawing.
- The five primary line types are construction lines, object lines, hidden lines, centerlines, and border lines.
- Dimensioning is a process used to describe the size of the object as well as the location of different features of the design.
- The two line types commonly used in dimensioning are dimension lines and extension lines.
- Industry guidelines allow for use of standard guidelines as well as industry- or organization-specific guidelines.

Know and Understand

Answer the following questions using the information provided in this chapter.

1. Engineers use _____ to further develop and communicate their designs.
   A. photographs
   B. drawings
   C. written reports
   D. All of the above.
2. Which of the following is a type of working drawing?
   A. Detail drawing
   B. Schematic drawing
   C. Assembly drawing
   D. All of the above.
3. _____ drawings are used to show how different parts are connected together to form a system.
   A. Orthographic
   B. ANSI
   C. Assembly
   D. Schematic
4. *True or False?* All orthographic drawings are detail drawings.
5. *True or False?* Visualization is the ability to mentally see a representation of a product for which there is no physical object.
6. One-view drawings are used to show _____ objects.
   A. flat
   B. cylindrical
   C. rectangular
   D. None of the above.
7. A(n) _____ drawing is used to communicate a design to someone who does not understand orthographic drawings.
   A. assembly
   B. pictorial
   C. orthographic
   D. detail
8. Which type of drawing do engineers use to highlight one feature of an object?
   A. Isometric
   B. Oblique
   C. Perspective
   D. Orthographic
9. *True or False?* In engineering drawings, symbols are used to show the properties of a specific object.

10. Identify each of the following line types.
    A.
    B.
    C.
    D.
    E.
11. *True or False?* The three types of dimensions in a drawing are size dimensions, location dimensions, and shape dimensions.
12. A(n) _____ is a line with an arrow on the end, pointing to the feature.
    A. leader
    B. feature
    C. extension
    D. dimension
13. *True or False?* Engineers within different disciplines use the same types of drawings.

Apply and Analyze

1. Why is communicating solutions important?
2. Explain the difference between a detail drawing and an assembly drawing.
3. Explain when you would use the following drawings:
    A. One-view drawings
    B. Two-view drawings
    C. Three-view drawings
4. Explain the difference between dimension lines and extension lines.
5. List three different types of dimensions.

Critical Thinking

1. Where have you seen a pictorial drawing? What was this pictorial drawing trying to communicate?
2. What are some examples where engineers used the triangle theorem to solve problem?
3. What are some engineered objects that are similar to an object, but created on a different scale?
4. What types of symbols do you see in your surroundings? Develop a symbol that would be useful for your home or classroom to provide information to others.

Communicating about Engineering

1. **Speaking.** Working in a group, brainstorm ideas for creating classroom tools (posters, flash cards, and/or games, for example) that will help your classmates learn and remember the different line types used in drawings. Choose the best idea(s) and then delegate responsibilities to group members for constructing the tools and presenting the final products to the class.
2. **Speaking.** Make a collage. Using pictures from magazines, create a collage that helps you remember drawing classifications. Show and discuss your collage in a group of four or five classmates. Are the other members of your group able to determine the drawing classification that you tried to represent?

ACTIVITY

6-1

Orthographic Drawings

Engineers use different types of orthographic drawing techniques to produce drawings that show details of their designs. Orthographic drawings can have one, two, or three views, depending on the shape of the object. In this activity, you will create orthographic drawings using different techniques.

Objectives

After completing this activity, you will be able to:

- Draw the missing views in an orthographic drawing.
- Dimension an orthographic drawing.

Materials

- Drawing tools
- Pencil
- Drawing paper

Procedure

1. Identify the missing view(s) in **Figure A** and in **Figure B**.
2. Use the information from the provided views to create the missing view(s). Draw them on your drawing paper.
3. Include different line types as appropriate.
4. Provide appropriate dimensioning to the drawings where necessary.

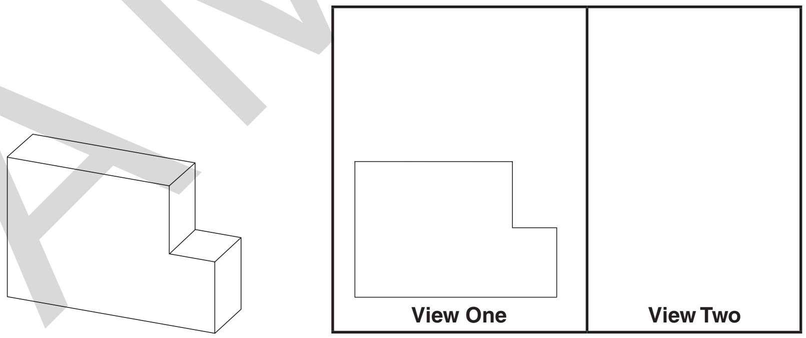

Figure A.

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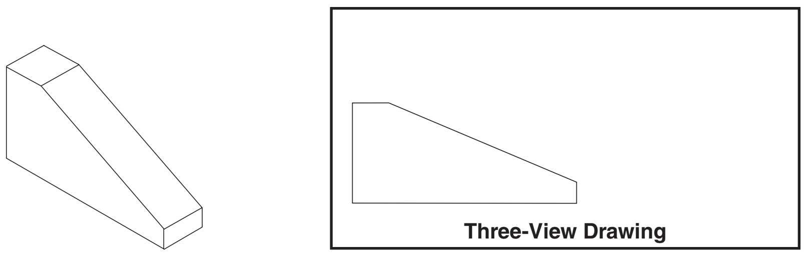

Figure B.

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Reflective Questions

1. Why were the missing views needed?
2. Did you need to add dimensions to the object? If so, why?

ACTIVITY

6-2

Perspective Drawings

Engineers use perspective drawings to show an object from a specific point of view. Engineers may use a one-, two-, or three-point perspective. In this activity, you will draw a perspective drawing of an object provided by your teacher.

Objectives

After completing this activity, you will be able to:

- Determine the appropriate type of perspective drawing to communicate a design.
- Draw a perspective drawing.

Materials

- Drawing tools
- Blank sheets of paper

Procedure

1. View the object provided by your teacher.
2. Visualize the perspective drawing.
3. Select the appropriate method (one-, two-, or three-point perspective drawing).
4. Using your own paper, complete the perspective drawing using the method suggested in the chapter.
5. Communicate the design with your teacher.

Reflective Questions

1. What details are you able to show with a perspective drawing?
2. Why would an engineer want to use a perspective drawing?
3. How did you select your vanishing point?