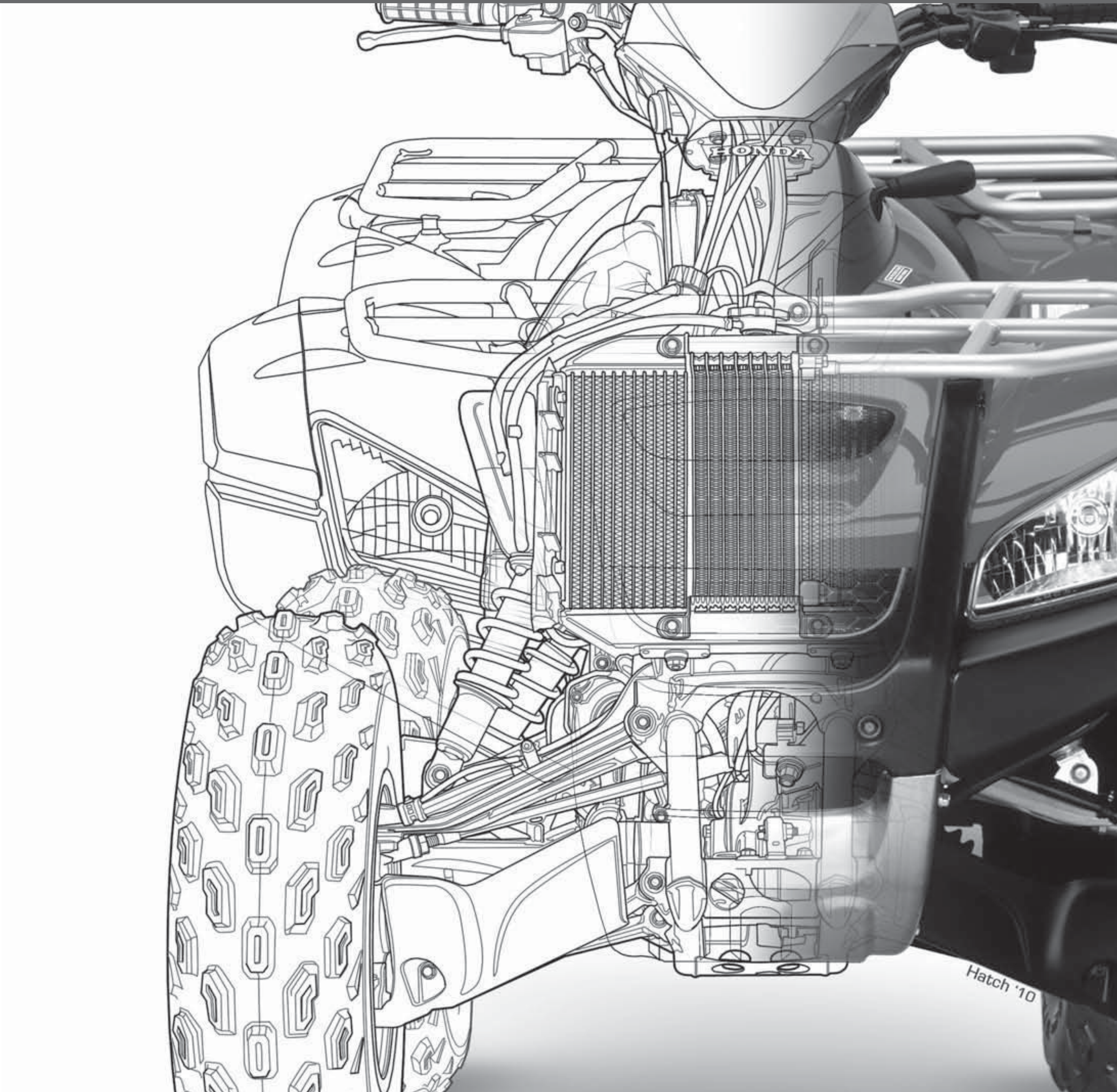
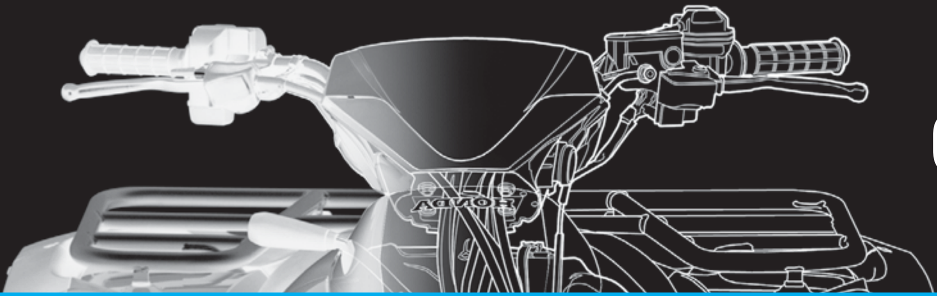
3 SECTION

Drafting Views and Annotations





CHAPTER 8

Multiviews

LEARNING OBJECTIVES

After completing this chapter, you will:

- Select appropriate views for presentation.
- Prepare single- and multiview drawings.
- Create detail views.
- Draw view enlargements.
- Establish runouts.
- Explain the difference between first- and third-angle projection.
- Create multiview drawings using first- and third-angle projection.
- Prepare formal multiview drawings from an engineer's sketch and actual industry layouts.

THE ENGINEERING DESIGN APPLICATION

The engineer has just handed you a sketch of a new part design (see Figure 8.1). The engineer explains that a multiview drawing is needed on the shop floor as soon as possible so a prototype can be manufactured and tested. Your responsibility as the engineering drafter is to create a drawing that shows the appropriate number of views and all necessary manufacturing information. Based on drafting guidelines, you first decide which view should be the front view. Having established the front view, you must now determine what other views are required in order to show all the features of the part. Using visualization techniques based on the glass box helps you to decide which views are needed (see Figure 8.2). Unfolding the box puts all of the views in

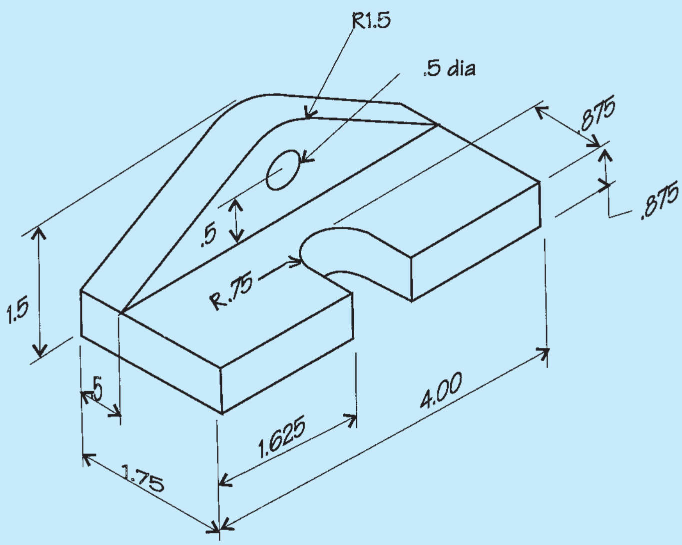


FIGURE 8.1 Engineer's rough sketch.

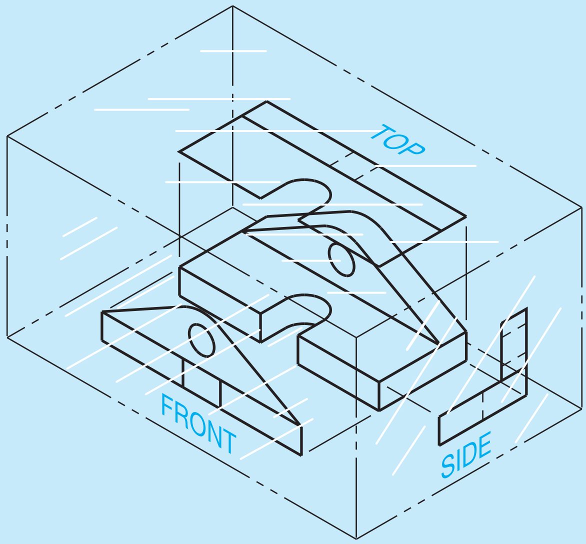


FIGURE 8.2 Using the glass box principle to visualize the needed views.

their proper positions. Now that you have properly visualized the part in your mind, you create a sketch of the proposed view layout. Using your sketch as a guide, you complete the formal drawing using the multiviews shown in Figure 8.3.

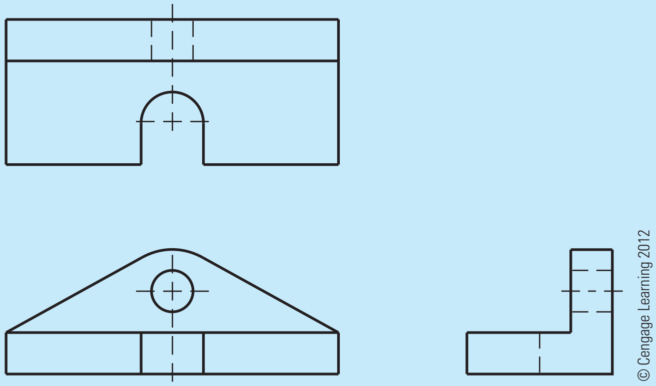


FIGURE 8.3 A multiview drawing of the part without dimensions.

STANDARDS

ASME/ISO This chapter is developed in accordance with the American Society of Mechanical Engineers (ASME) standards publication ASME Y14.3, *Multi and Sectional View Drawings*. The content of this discussion provides an in-depth analysis of the techniques and methods of multiview presentation. Defined and described in this chapter are practices related to orthographic projection, internationally recognized projection systems, and alternate view definition systems used by the International Organization for Standardization (ISO).

Actual objects such as your pencil, computer monitor, or this textbook are typically easy to recognize and visualize because they are three-dimensional (3-D) physical items. However, complex 3-D items are difficult to describe and can be even more complicated to draw and dimension because there is too much depth and extensive detail. As a result, the drafting industry has historically used a system of two-dimensional (2-D) views created using orthographic projection. Orthographic projection is used to change physical objects and 3-D ideas into 2-D drawings that effectively describe the design and features of an object, so the object can be documented and manufactured.

Orthographic projection is any projection of the features of an object onto an imaginary plane called a **plane of projection**. The projection of the features of the object is made by lines of sight that are perpendicular to the plane of projection. When a surface of the object is parallel to the plane of projection, the surface appears in its true size and shape on the plane of projection. The view that shows the actual shape of the object is called the **true geometry view**. In Figure 8.4, the plane of projection is parallel to the surface of the object. The line of sight (projection from the object) is perpendicular to the plane of projection. Notice also that the object appears three-dimensional (width, height, and depth) whereas the view on the plane of projection has only two dimensions (width and height). In situations in which the plane of projection is not parallel to the surface of the object, the resulting orthographic view is foreshortened, or shorter than true length (see Figure 8.5).

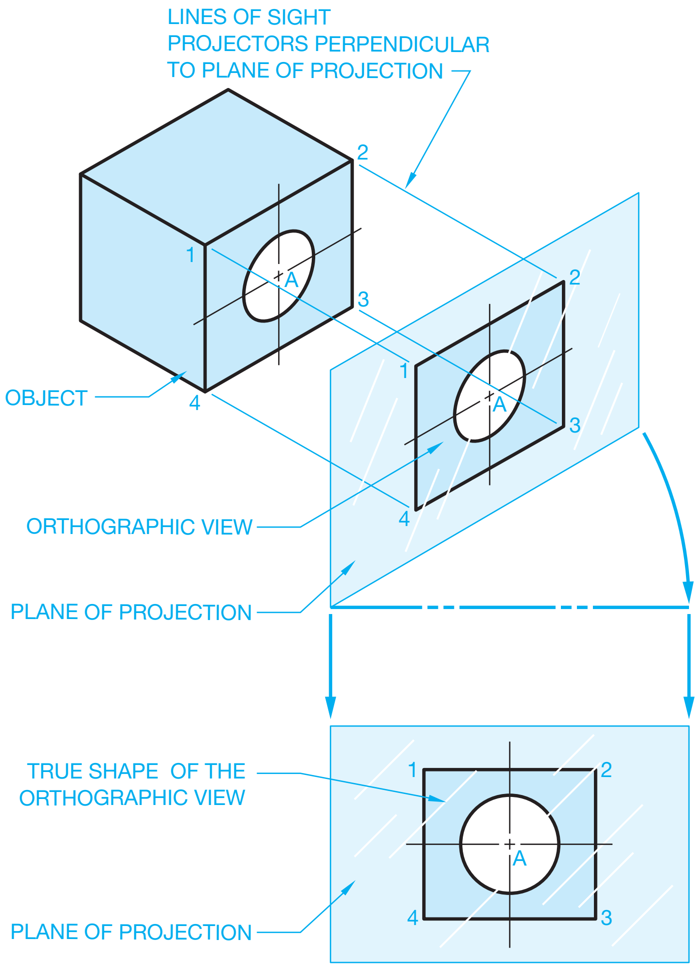


FIGURE 8.4 Orthographic projection to form orthographic view. *© Cengage Learning 2012*

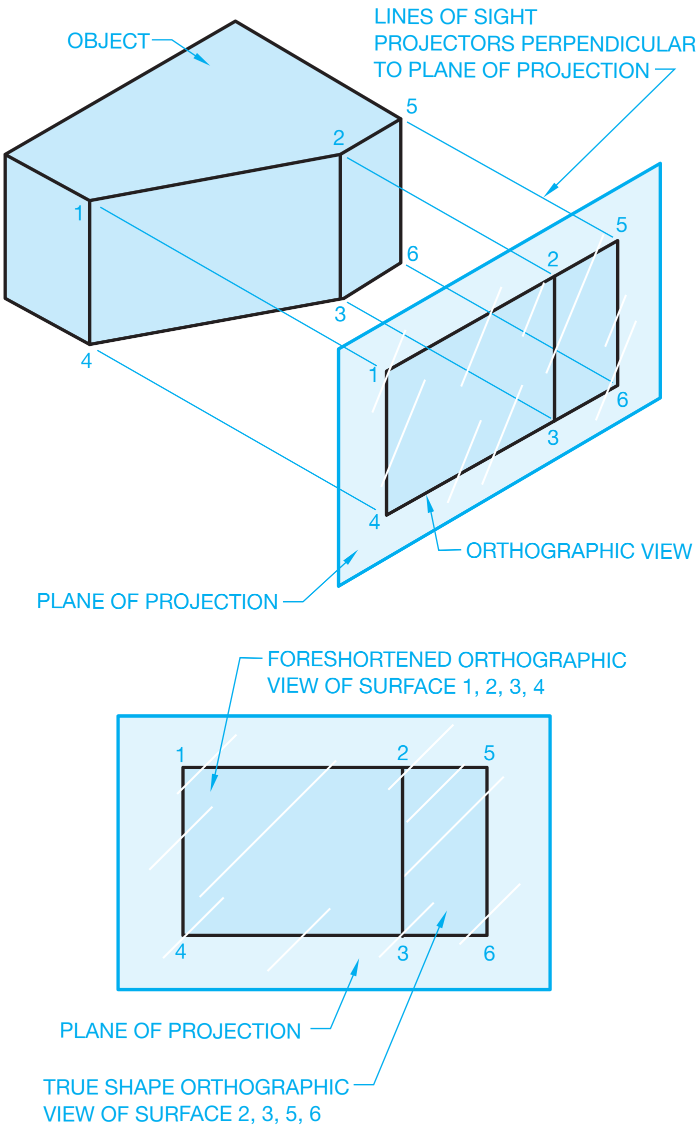


FIGURE 8.5 Projection of a foreshortened orthographic surface. *© Cengage Learning 2012*

MULTIVIEWS

Multiview projection establishes views of an object projected on two or more planes of projection by using orthographic projection techniques. The result of multiview projection is a multiview drawing. A **multiview drawing** represents the shape of an object using two or more views. Consideration should be given to the choice and number of views used, so the surfaces of the object are shown in their true size and shape when possible.

It is generally easier to visualize a 3-D picture of an object than to visualize a 2-D drawing. In mechanical drafting, however, the common practice is to prepare completely dimensioned detail drawings using 2-D views known as **multiviews**. Figure 8.6 shows an object represented by a 3-D drawing, also called a **pictorial**, and three 2-D views, or multiviews, also known as orthographic projection. The multiview method of drafting represents the **shape description** of the object.

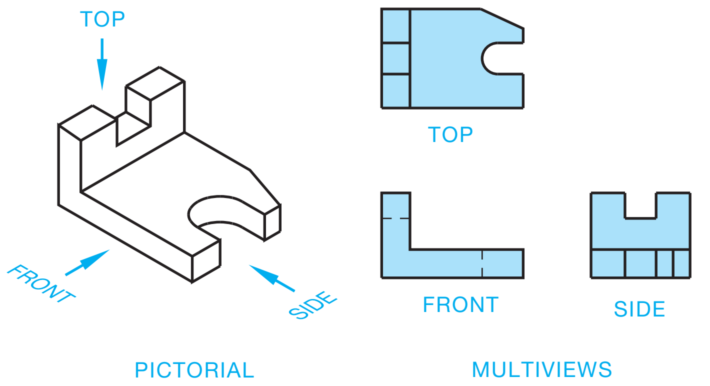


FIGURE 8.6 A pictorial view and its relationship to multiviews of the same part. *© Cengage Learning 2012*

The Glass Box Visualization Method

If the object in Figure 8.6 is placed in a glass box so the sides of the box are parallel to the major surfaces of the object, you can project those surfaces onto the sides of the glass box and create multiviews. Imagine the sides of the glass box are the planes of projection previously discussed (see Figure 8.7). If you look at all sides of the glass box, then you have six total views: front, top, right side, left side, bottom, and rear. Now unfold the glass box as if the corners were hinged about the front (except the rear view) as demonstrated in Figure 8.8. These hinge lines are commonly called *fold lines* or *reference lines*.

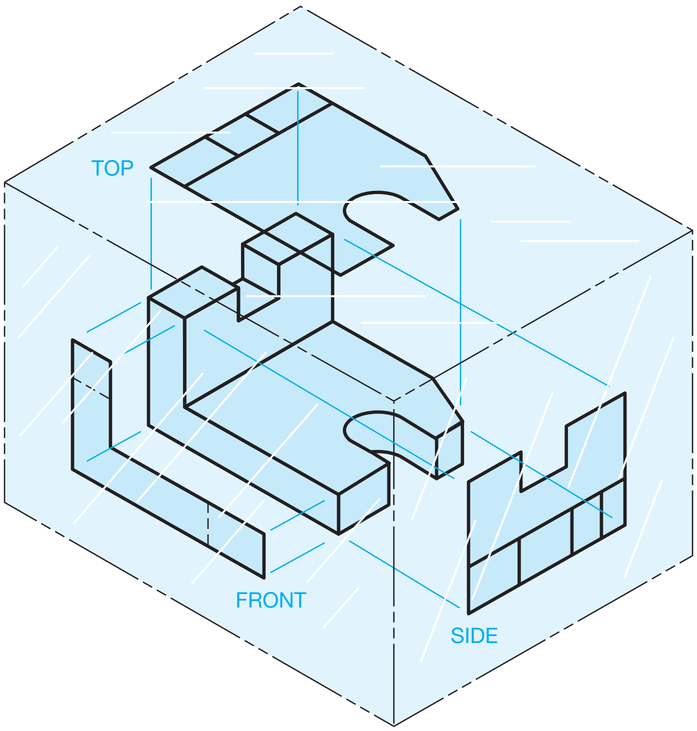


FIGURE 8.7 The glass box principle. *© Cengage Learning 2012*

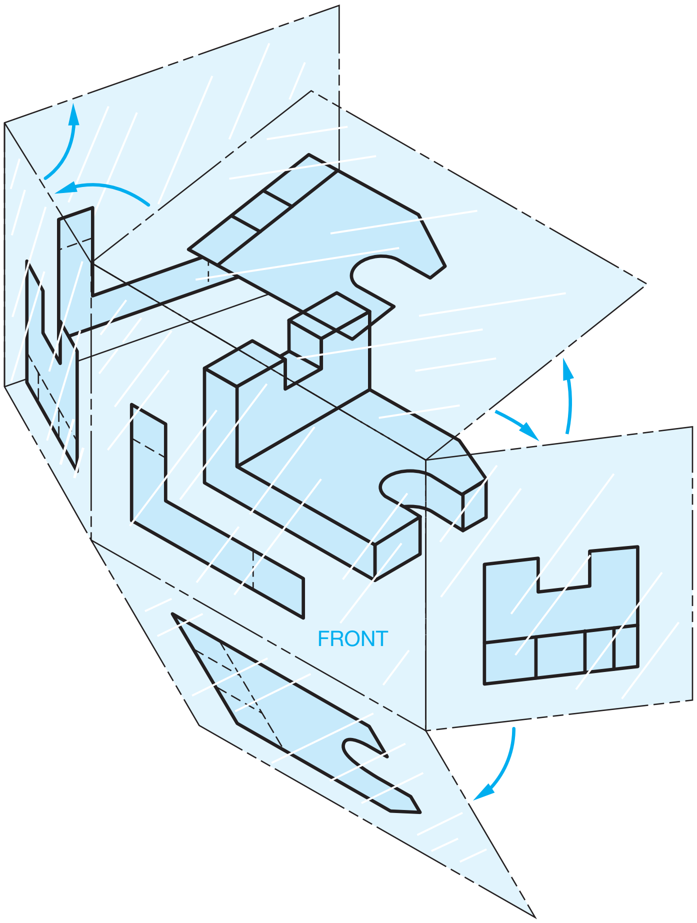


FIGURE 8.8 Unfolding the glass box at the hinge lines, also called *fold lines* or *reference lines*. *© Cengage Learning 2012*

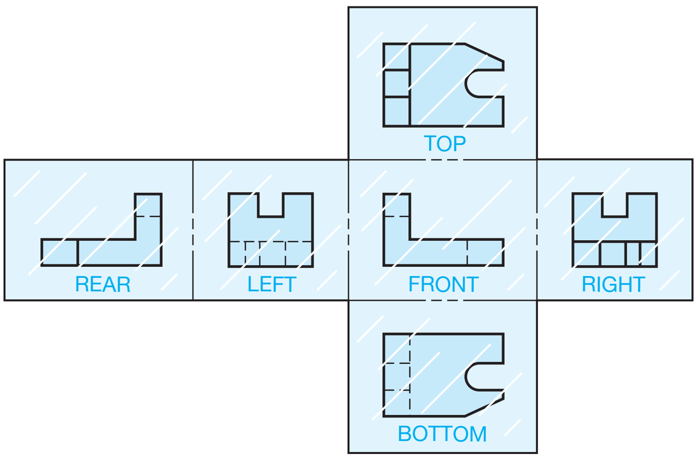


FIGURE 8.9 Glass box unfolded. *© Cengage Learning 2012*

Completely unfold the glass box onto a flat surface and you have the six views of an object represented in multiview. Figure 8.9 shows the glass box unfolded. Notice the views are labeled FRONT, TOP, RIGHT, LEFT, REAR, and BOTTOM. This is the arrangement that the views are always found in when using multiviews in third-angle projection. **Third-angle projection** is the principal multiview projection used in the United States. **First-angle projection** is commonly used in other countries. Additional third- and first-angle projection coverage is provided later in this chapter.

Look at Figure 8.9 in more detail so you can observe the common items between views. Knowing how to identify features of the object common between views aids you in visualizing multiviews. Notice in Figure 8.10 that the views are aligned. The top view is directly above and the bottom view is directly below the front view. The left-side view is directly to the left and the right-side view is directly to the right of the front view. This format allows you to project points directly from one view to the next to help establish related features on each view.

Now look closely at the relationships between the front, top, and right-side views. A similar relationship exists with the left-side view. Figure 8.11 shows a 45° line projected from the corner of the fold between the front, top, and side views. The 45° line is often called a **mitre line**. This 45° line is used as an aid

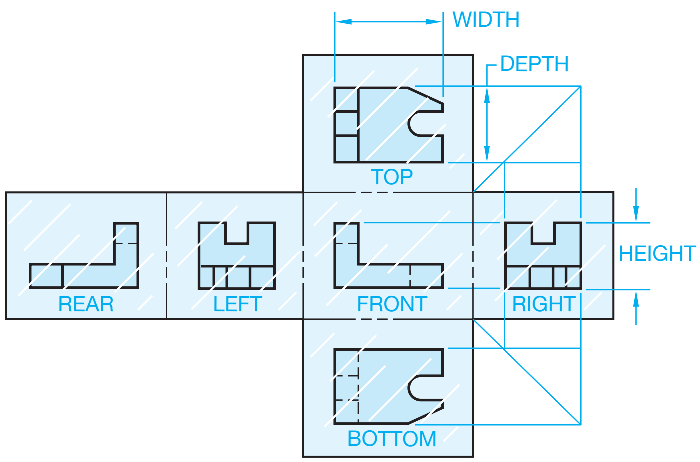


FIGURE 8.10 View alignment. *© Cengage Learning 2012*

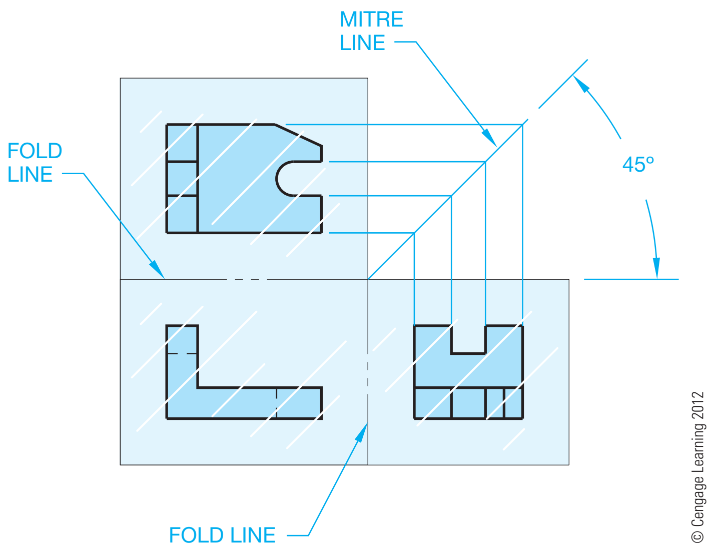


FIGURE 8.11 The 45° projection line.

in projecting views between the top and right-side views in this example. All of the features established on the top view can be projected to the 45° line and then down onto the side view. This projection works because the depth dimension is the same between the top and side views. The reverse is also true. Features from the side view can be projected to the 45° line and then over to the top view.

The same concept of projection developed in Figure 8.11 using the 45° line also works by using arcs with the arc center at the intersection of the horizontal and vertical fold lines. The arcs establish the common relationship between the top and side views as shown in Figure 8.12. Another method commonly used to transfer the size of features from one view to the next is to use measurements to transfer distances from the fold line of the top view to the fold line of the side view. The relationships between the fold line and these two views are the same, as shown in Figure 8.13.

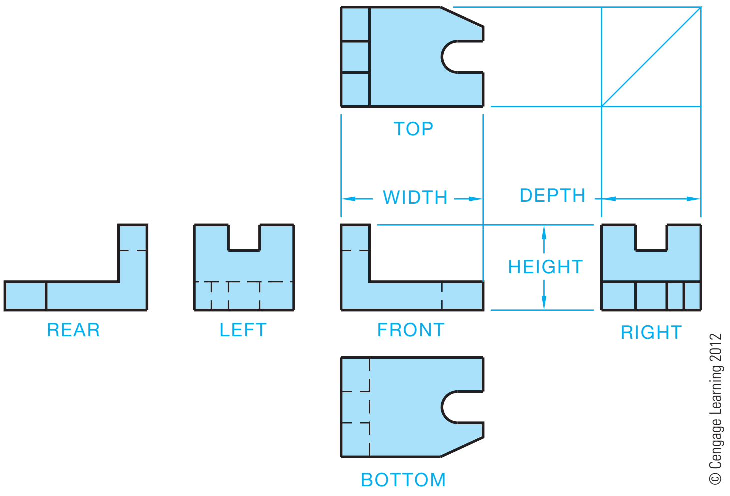


FIGURE 8.14 Multiview orientation of the six principal views.

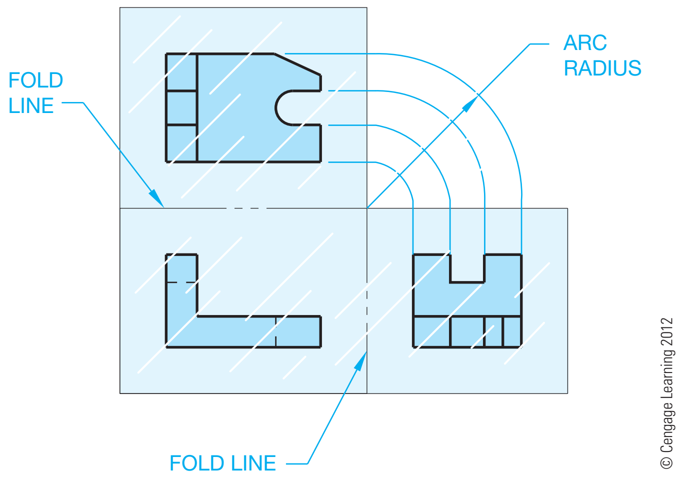


FIGURE 8.12 Projection between views with arcs.

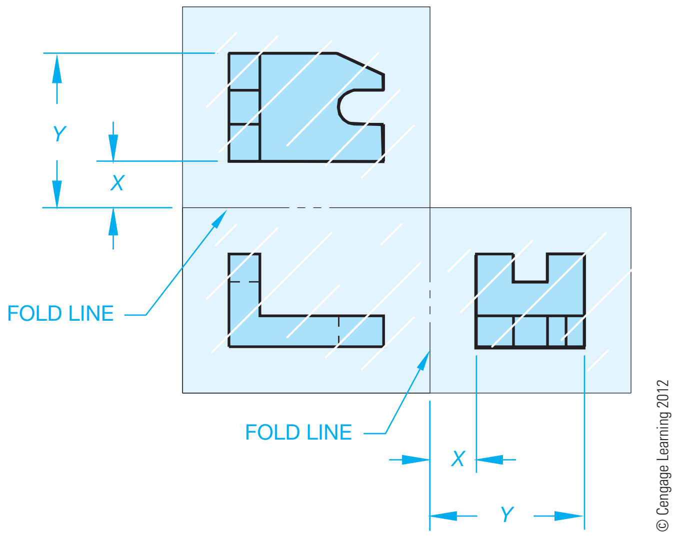


FIGURE 8.13 Using measurements to transfer view projections.

The front view is usually the most important view and the one from which the other views are established. There is always one dimension common between adjacent views. For example, the width is common between the front and top views, and the height is common between the front and side views. Knowing this allows you to relate information from one view to another. Look again at the relationship between the six views shown in Figure 8.14.

THIRD-ANGLE PROJECTION

The primary method of multiview projection described in this chapter is known as third-angle projection. Third-angle projection is the method of view arrangement commonly used in the United States. In the previous discussion on multiview projection, the object was placed in a glass box so the sides of the glass box were parallel to the major surfaces of the object. Next, the object surfaces were projected onto the adjacent surfaces of the glass box. This gave the same effect as if your line of sight is perpendicular to the surface of the box and looking directly at the object, as shown in Figure 8.15. With the multiview concept in mind, assume an area of space is divided into four quadrants, as shown in Figure 8.16.

If the object is placed in any of these quadrants, the surfaces of the object are projected onto the adjacent planes. When placed in the first quadrant, the method of projection is known as *first-angle projection*. Projections in the other quadrants are termed *second-*, *third-*, and *fourth-angle projections*. Second- and fourth-angle projections are not used, though first- and third-angle projections are common.

Third-angle projection is established when you take the glass box from Figure 8.15 and place it in quadrant 3 from Figure 8.16. Figure 8.17 shows the relationship of the glass box to the projection planes in the third-angle projection. In this quadrant, the projection plane is between your line of sight and

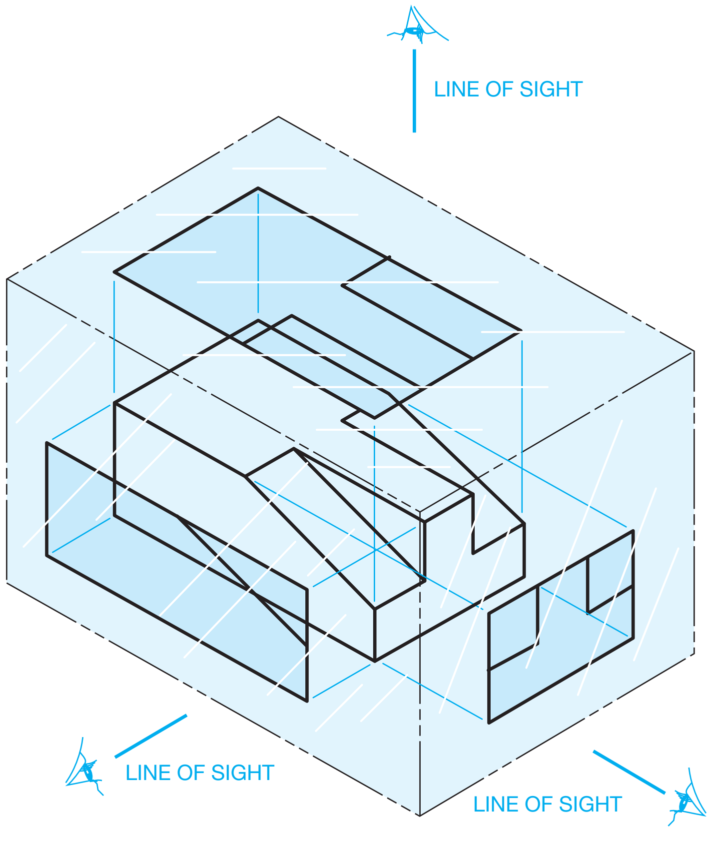


FIGURE 8.15 Glass box in third-angle projection. *© Cengage Learning 2012*

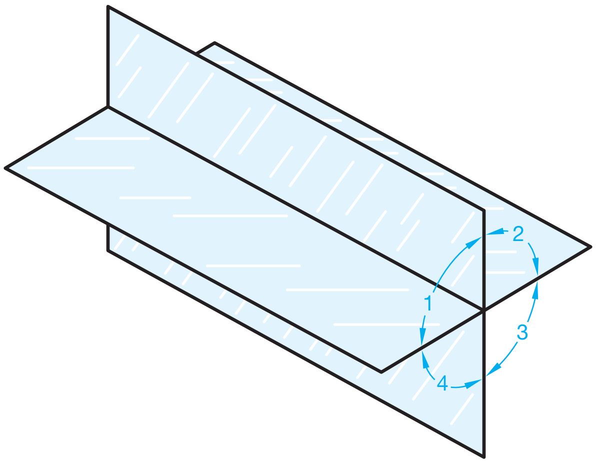


FIGURE 8.16 Quadrants of spatial visualization. *© Cengage Learning 2012*

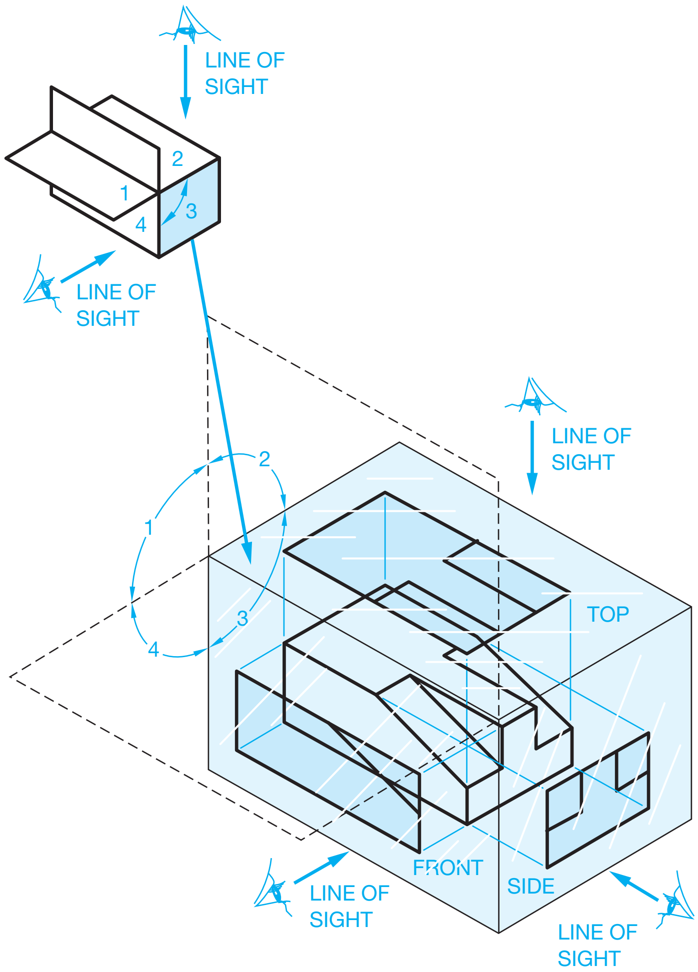


FIGURE 8.17 Glass box placed in the third quadrant for third-angle projection. *© Cengage Learning 2012*

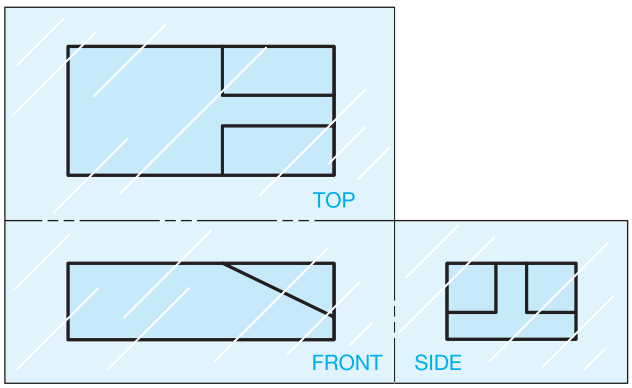


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FIGURE 8.18 Views established using third-angle projection.

the object. When the glass box in the third-angle projection quadrant is unfolded, the result is the multiview arrangement previously described and shown in Figure 8.18.

A third-angle projection drawing is identified by the third-angle projection symbol. The angle of projection symbol typically appears in the angle of projection block near the title block, as shown in Chapter 2, *Drafting Equipment, Media, and Reproduction Methods*. Figure 8.19 shows the standard third-angle projection symbol as specified by ASME Y14.3.

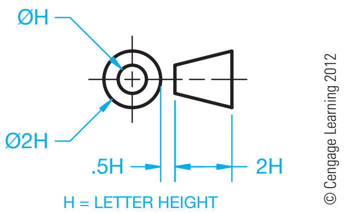

FIGURE 8.19 Third-angle projection symbol. ASME Y14.3 defines the projection symbol dimensions based on a .12 in. (3 mm) letter height. A larger symbol is usually more appropriate for use in the angle of projection block.

FIRST-ANGLE PROJECTION

First-angle projection is commonly used in countries other than the United States. First-angle projection places the glass box in the first quadrant of Figure 8.16. Views are established by projecting surfaces of the object onto the surface of the glass box. In this projection arrangement, the object is between your line of sight and the projection plane, as shown in Figure 8.20. When the glass box in the first-angle projection quadrant is unfolded, the result is the multiview arrangement shown in Figure 8.21.

A first-angle projection drawing is identified by the first-angle projection symbol. The angle of projection symbol typically appears in the angle of projection block near the title block, as shown in Chapter 2, *Drafting Equipment, Media, and Reproduction Methods*. Figure 8.22 shows the standard first-angle projection symbol as specified by ASME Y14.3. Figure 8.23 shows a comparison of the same object in first- and third-angle projections.

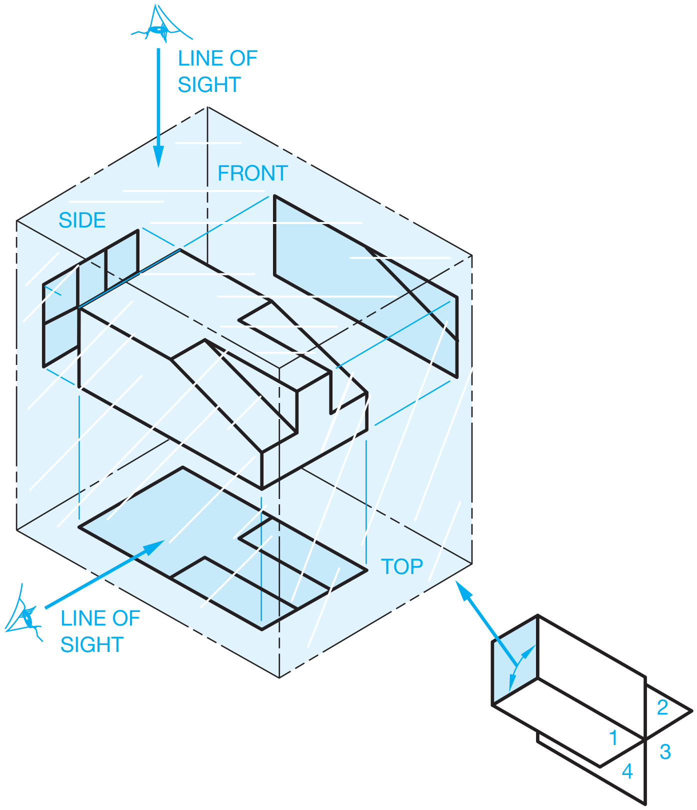

FIGURE 8.20 Glass box in first-angle projection. *© Cengage Learning 2012*

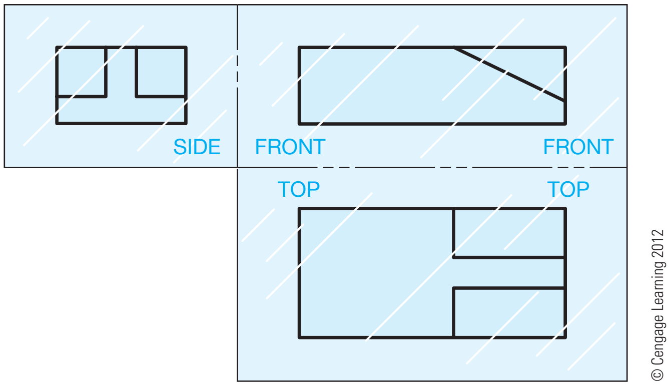

FIGURE 8.21 Views established using first-angle projection.

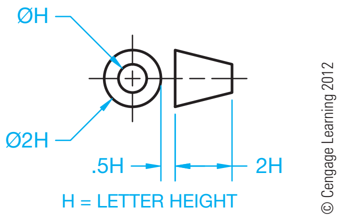

FIGURE 8.22 First-angle projection symbol. ASME Y14.3 defines the projection symbol dimensions based on a .12 in. (3 mm) letter height. A larger symbol is usually more appropriate for use in the angle of projection block.

VIEW SELECTION

Although there are six primary views that you can select to describe an object completely, it is seldom necessary to use all six views. As a drafter, you must decide how many views are needed to represent the object properly. If you draw too many views, you make the drawing too complicated and are wasting time, which costs your employer money. If you draw too few views, then you have not completely described the object. The manufacturing department then has to waste time trying to determine the complete description of the object, which again costs your employer money.

Selecting the Front View

Usually, you should select the front view first. The front view is generally the most important view and, as you learned from the glass box description, it is the origin of all other views. There is no exact way for everyone to select the same front view always, but there are some guidelines to follow. The front view should:

- Represent the most natural position of use.
- Provide the best shape description or most characteristic contours.

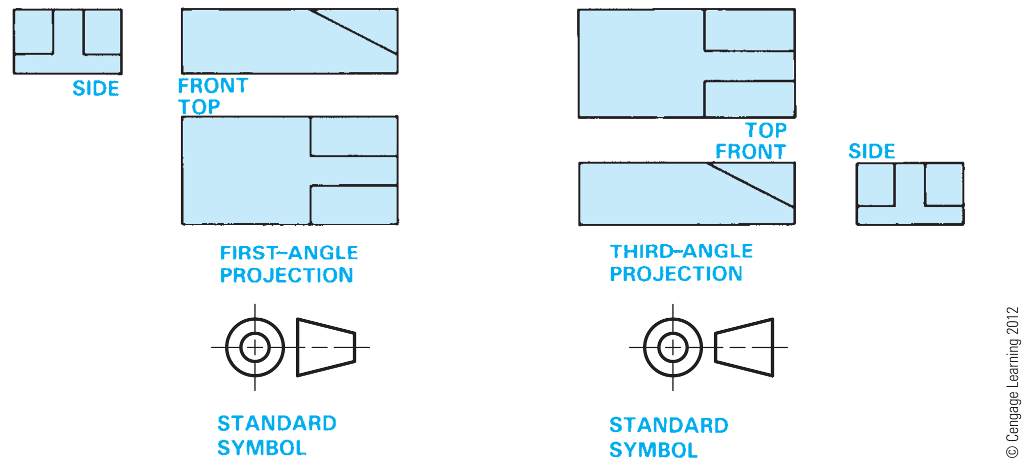

FIGURE 8.23 First-angle and third-angle projection compared.

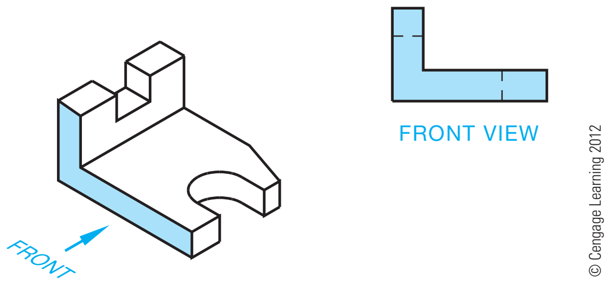

FIGURE 8.24 Front-view selection.

- Have the longest dimension.
- Have the fewest hidden features.
- Be the most stable and natural position.

Look at the pictorial drawing in Figure 8.24. Notice the front-view selection. This front-view selection violates the guidelines for best shape description and the fewest hidden features. However, the selection of any other view as the front would violate other rules, so in this case there is possibly no correct answer. Given the pictorial drawings in Figure 8.25, identify the view that you believe is the best front view for each object. The figure caption provides possible answers. More than one answer is given for some of the objects, with the first answer being the preferred choice.

Selecting Two or Three Views

Use the same rules when selecting other views needed as you do when selecting the front view:

- Most contours.
- Longest side.
- Least hidden features.
- Best balance or position.

Given the six views of the object in Figure 8.26, which views would you select to describe the object completely? If your

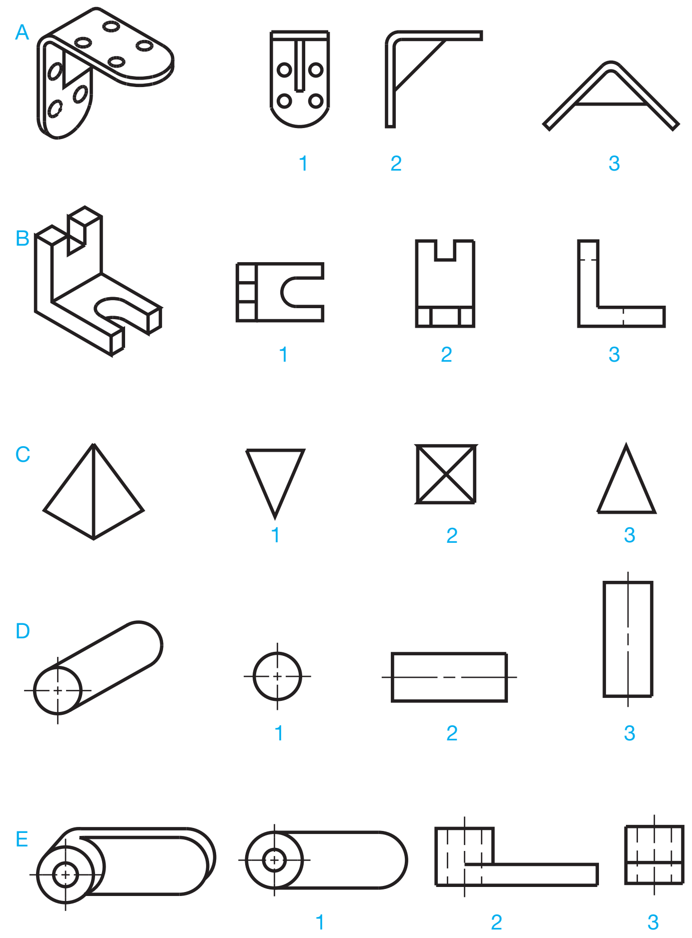

FIGURE 8.25 Select the best front views that correspond to the pictorial drawings at the left. You can make a first and second choice. © *Cengage Learning 2012*

selection is the front, top, and right side, then you are correct. Now take a closer look. Figure 8.27 shows the selected three views. The front view shows the best position and the longest side, the top view clearly represents the angle and the arc, and

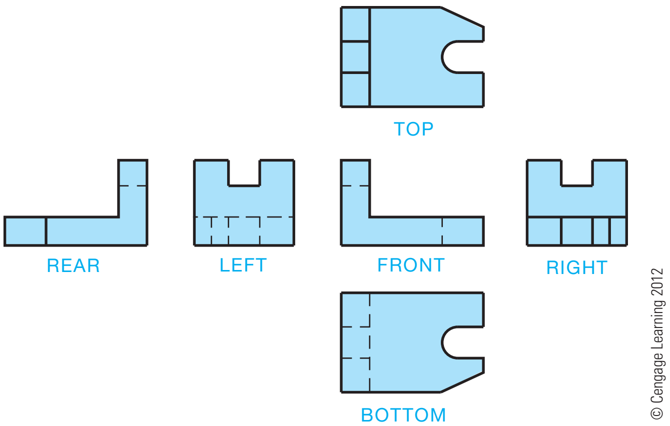

FIGURE 8.26 Select the necessary views to describe the object from the six principal views available.

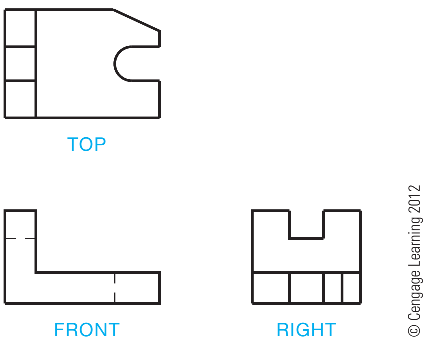

FIGURE 8.27 The three selected views.

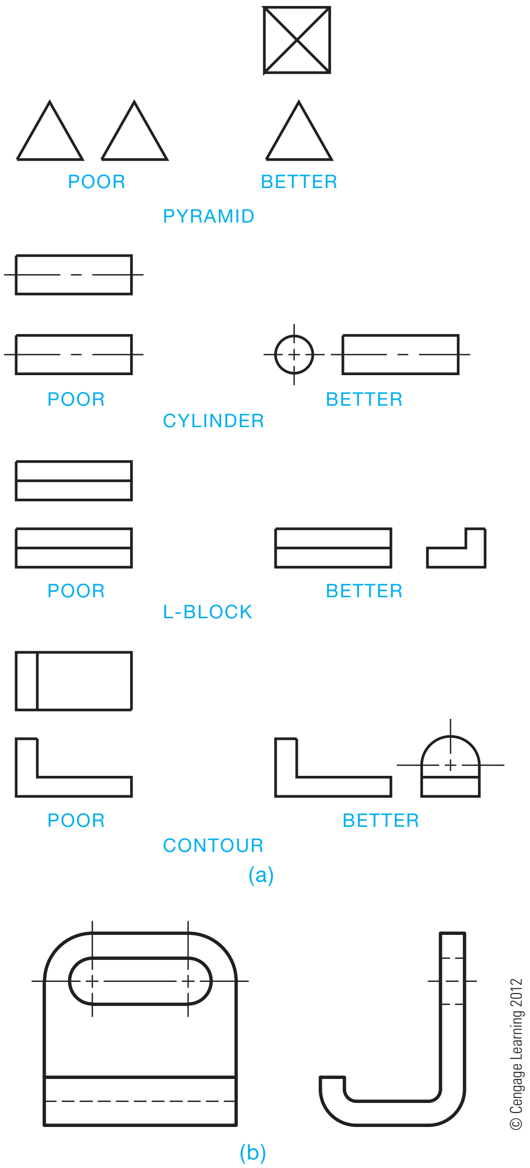

FIGURE 8.28 (a) Selecting two views of objects. (b) A two-view drawing.

the right-side view shows the notch. Any of the other views have many more hidden features. You should always avoid hidden features if you can.

NOTE: Look at Figures 8.26 and 8.27 and notice the front view that this drafter selected. Now look at the rear view in Figure 8.26. You can easily argue that the drafter could have selected the rear view in Figure 8.26 as the preferred front view, and you would be correct. The rear view in Figure 8.26 has an object line representing a corner, where the front view has a hidden line. Keeping with the idea of minimizing hidden lines, the drafter probably should have selected the current rear view as the front view. The views that this drafter selected in Figure 8.27 still work to display the shape of the part, but the rear view would have been a better choice. This is the thinking process that you need to go through when selecting views.

It is not always necessary to select three views. Some objects can be completely described with two views or even one view. When selecting fewer than three views to describe an object, you must be careful which view, other than the front view, you select. Look at Figure 8.28a and notice the two views that are selected for each object. Whenever possible, spend some time looking at actual industry drawings. Doing this gives you a better understanding of how the views of an object are arranged. Figure 8.28b shows a two-view drawing.

Figure 8.29 is an industry drawing showing an object displayed using three views. Try to visualize the shape of this object in your mind and decide if you agree with the view selection provided by the person who created this drawing.

One-View Drawings

One-view drawings are also often practical. When an object has a uniform shape and thickness, more than one view is normally unnecessary. Figure 8.30 shows a gasket drawing in which the thickness of the part is identified in the materials specifications of the title block. The types of parts that easily fit into the one view category include gaskets, washers, spacers, and similar thin features.

Although two-view drawings are generally considered the minimum recommended views for a part, objects that are clearly

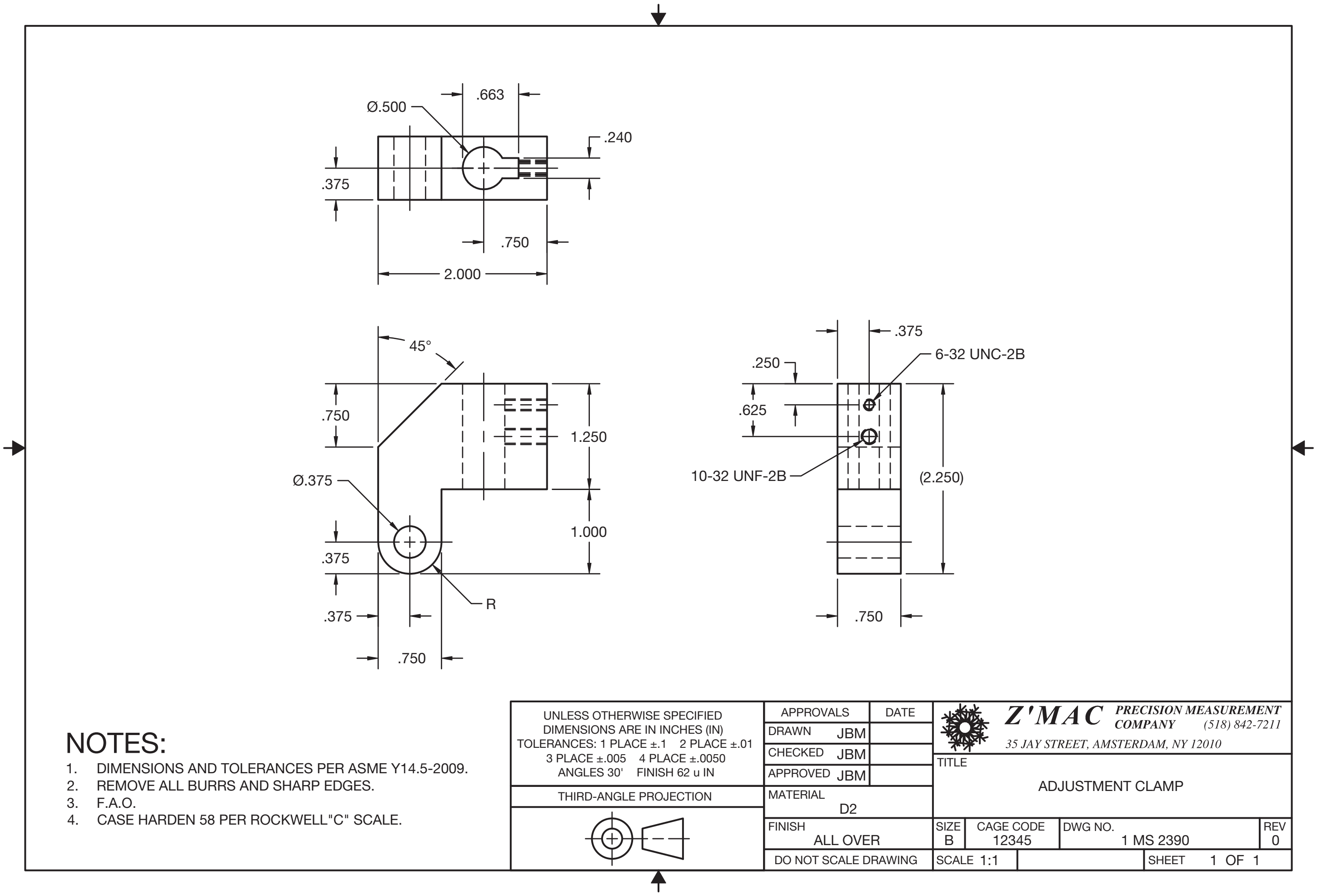

FIGURE 8.29 An actual industry drawing with three views used to describe the part. *Courtesy Jim B. MacDonald*

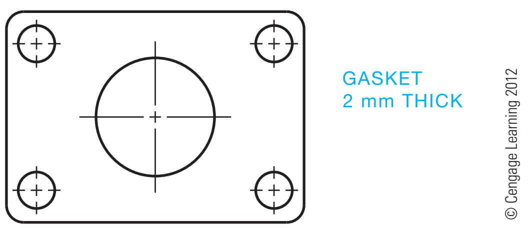

FIGURE 8.30 One-view drawing with thickness given in a note.

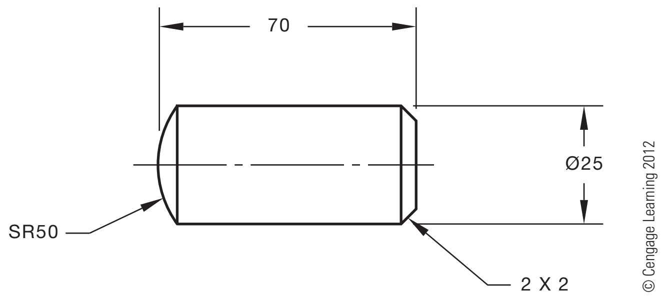

FIGURE 8.31 One-view drawing with the diameter specified in a dimension.

identified by shape and dimensional information can be drawn with one view as shown in Figure 8.31. In Figure 8.31, the shape of the pin is clearly identified by the 25 mm diameter. In this case, the second view would be a circle and would not necessarily add any more valuable information to the drawing. Keep this primary question in mind: Can the part be easily manufactured from the drawing without confusion? If there is any doubt, then the adjacent view should probably be drawn. As an entry-level drafter, you should ask your drafting supervisor to clarify the company policy regarding the number of views to be drawn. Figure 8.32 provides an actual industry drawing of an object with one view.

Partial Views

Partial views can be used when symmetrical objects are drawn in limited space or when there is a desire to simplify complex views. The top view in Figure 8.33 is a partial view. Notice how the short break line is used to show that a portion of the view is omitted. Caution should be exercised when using partial views, as confusion could result in some situations. If the partial view reduces clarity, then draw the entire view. When using CADD, it is easier to draw the full view.

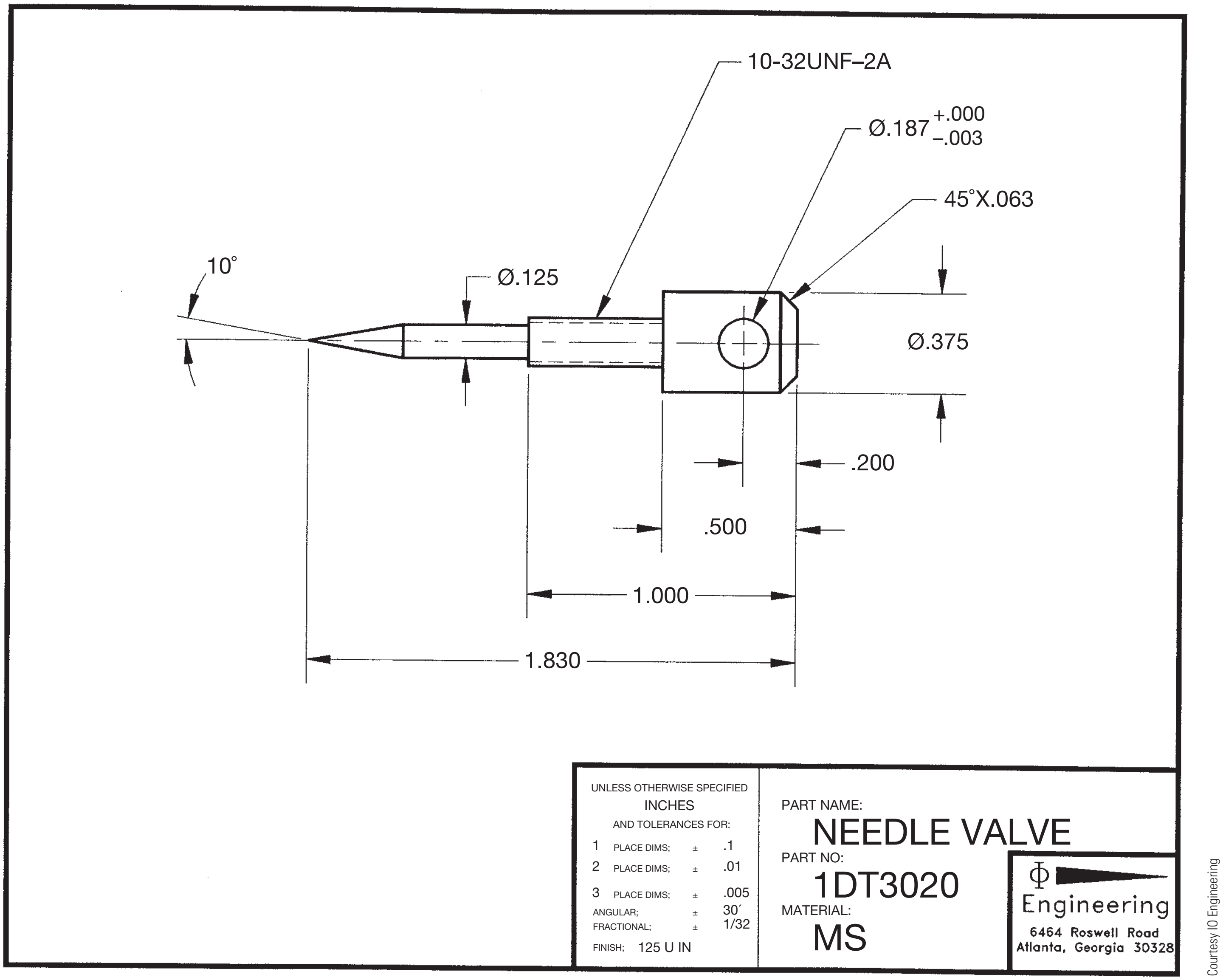

FIGURE 8.32 An actual industry drawing with one view used to describe the part.

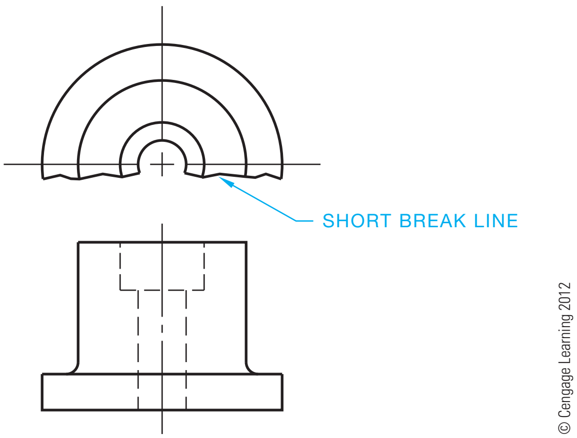

FIGURE 8.33 Partial view. A short break line is used to remove a portion of the top view. This practice should be used with caution and approved by your instructor or supervisor.

Detail View

A **detail view** can be used when part of a view has detail that cannot be clearly dimensioned due to the drawing scale or complexity. To establish a detail view, a thick phantom line circle is placed around the area to be enlarged. This circle is broken at a convenient location and an identification letter is centered in the break. The height of this letter is generally .24 in. (6 mm) minimum so it stands out from other text. Arrowheads are then placed on the line next to the identification letter, as shown in Figure 8.34. The arrowheads are generally twice the size of dimension-line arrowheads, so they show up better on the drawing. If the dimension-line arrowheads are .125 (3 mm) long on your drawing, then make the viewing plane line arrowheads .25 in. (6 mm) long. A detail view of the area is then placed in any convenient location in the field of the drawing. Detail views are generally enlarged to scales such as 2:1, 4:1, and 10:1.

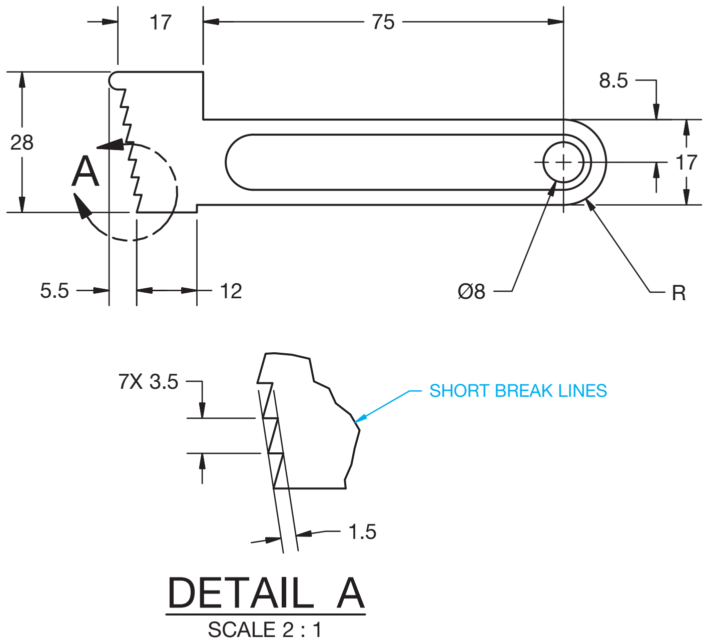

FIGURE 8.34 Using a detail view. *© Cengage Learning 2012*

The view enlargement provides clarity and ease of dimensioning the complex features. The view identification and scale is placed below the enlarged view, such as DETAIL A. The title text height is .24 in. (6 mm). An actual industry drawing with three principal views and a detail view is provided in Figure 8.35.

Alternate View Placement

It is always best to place entry-level views in the alignment based on the six principal views previously discussed. This helps ensure that the drawing is read based on traditional view-projection methods. However, alternate view placement can be used, if necessary. Using an alternate position for a view is possible when space on the sheet is limited. For example, the rear view can be placed in alignment with and to the right of the right-side view. The right- and left-side views can be placed next to and in alignment with the top view. Even though this possibility is suggested in ASME Y14.3, the practice should be avoided. Any use of this practice should be confirmed with your school or company standards. When sheet space is limited, it is normally best to use a larger sheet if allowed by your school or company.

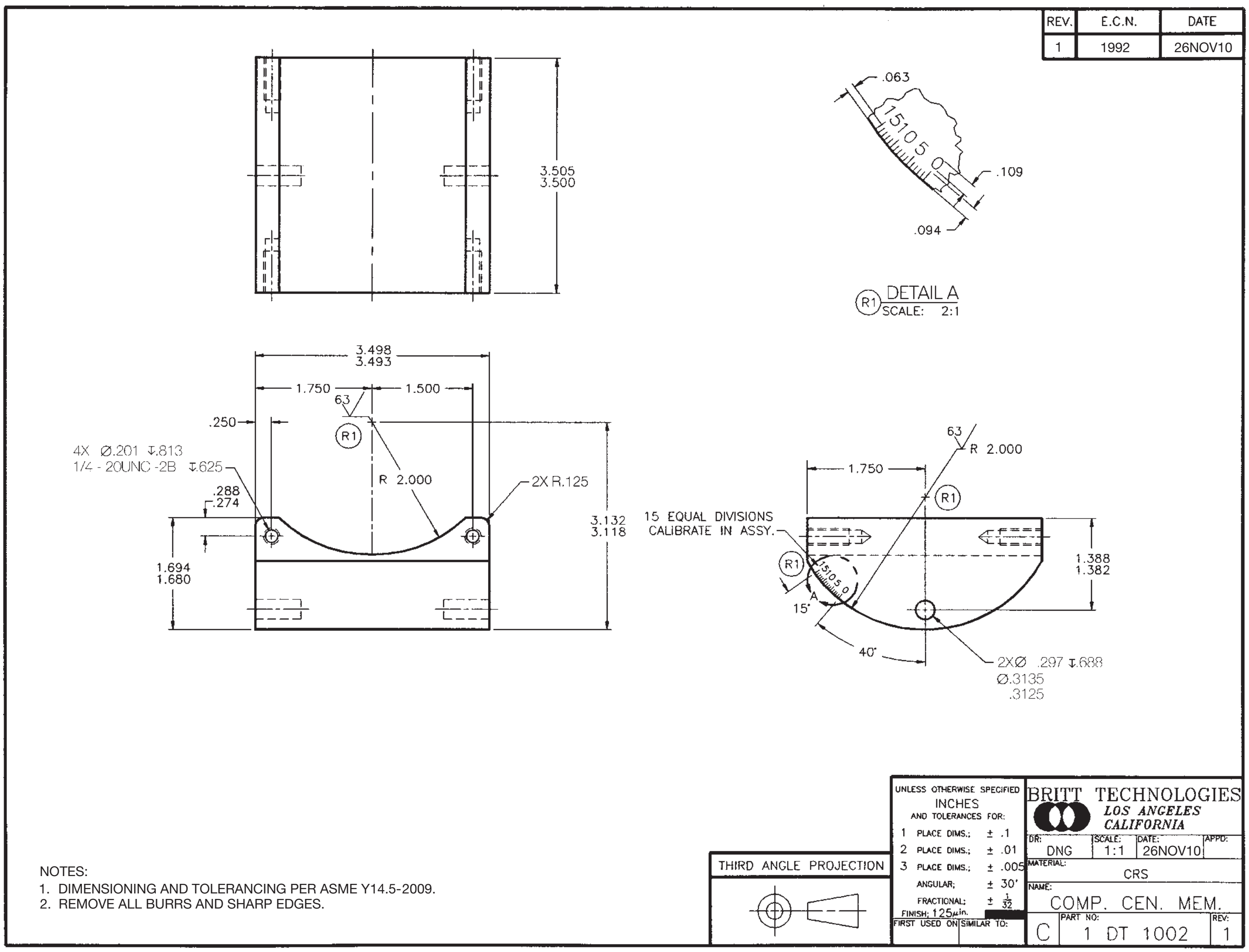

FIGURE 8.35 An actual industry drawing with three principal views and a view enlargement used to describe the part.

Removed Views

In some cases, it is necessary to place a view out of normal arrangement with the other views. The situations that can make this necessary are when there is limited space on the sheet or when you want to enlarge the view. **Removed views** are established by placing viewing plane lines that identify where the view is taken. Each end of the viewing plane line is labeled with a letter, such as A for the first removed view and B for the second removed view. Consecutive letters are used for additional removed views. The viewing-plane line arrowheads maintain the same 3:1 length-to-width ratio as dimension-line arrowheads. Viewing-plane line arrowheads are generally twice the size of dimension-line arrowheads, so they show up better on the drawing. If the dimension-line arrowheads are .125 (3 mm) long on your drawing, then make the viewing plane line arrowheads .25 in. (6 mm) long. This depends on the size of the drawing and your school or company standards. The view is then moved to a desired location on the drawing, and a title is placed below the view to correspond with its viewing plane line label, such as VIEW A-A. The title text height is .24 in. (6 mm). The removed view is kept in the same alignment as its normal arrangement. The removed view can be kept at the same scale as the other views or it can be enlarged. When the view is enlarged, the scale is placed under the view title, such as SCALE 2:1. The scale text height is .12 in. (3 mm) (see Figure 8.36a).

It is preferable to keep the removed view on the same sheet from where the view was taken. If a view is placed on a different sheet from where its viewing-plane line is located, then the sheet number and the zone of the cross-reference location are given with the view title, such as SEE SHEET 1 ZONE B4. All sheets of a multiple sheet drawing should be the same size. Each sheet has the same drawing number or part number. The sheets also have page numbers. For example, if there are three sheets, the first sheet is 1/3, the second sheet is 2/3, and the third sheet is 3/3. The format 1 OF 3, 2 OF 3, and 3 OF 3 can also be used. When a drawing has multiple sheets, the first sheet has the complete title block and other sheet blocks, including the angle of projection block and dimensioning and tolerance block. Additional sheets can have the same set of blocks, or

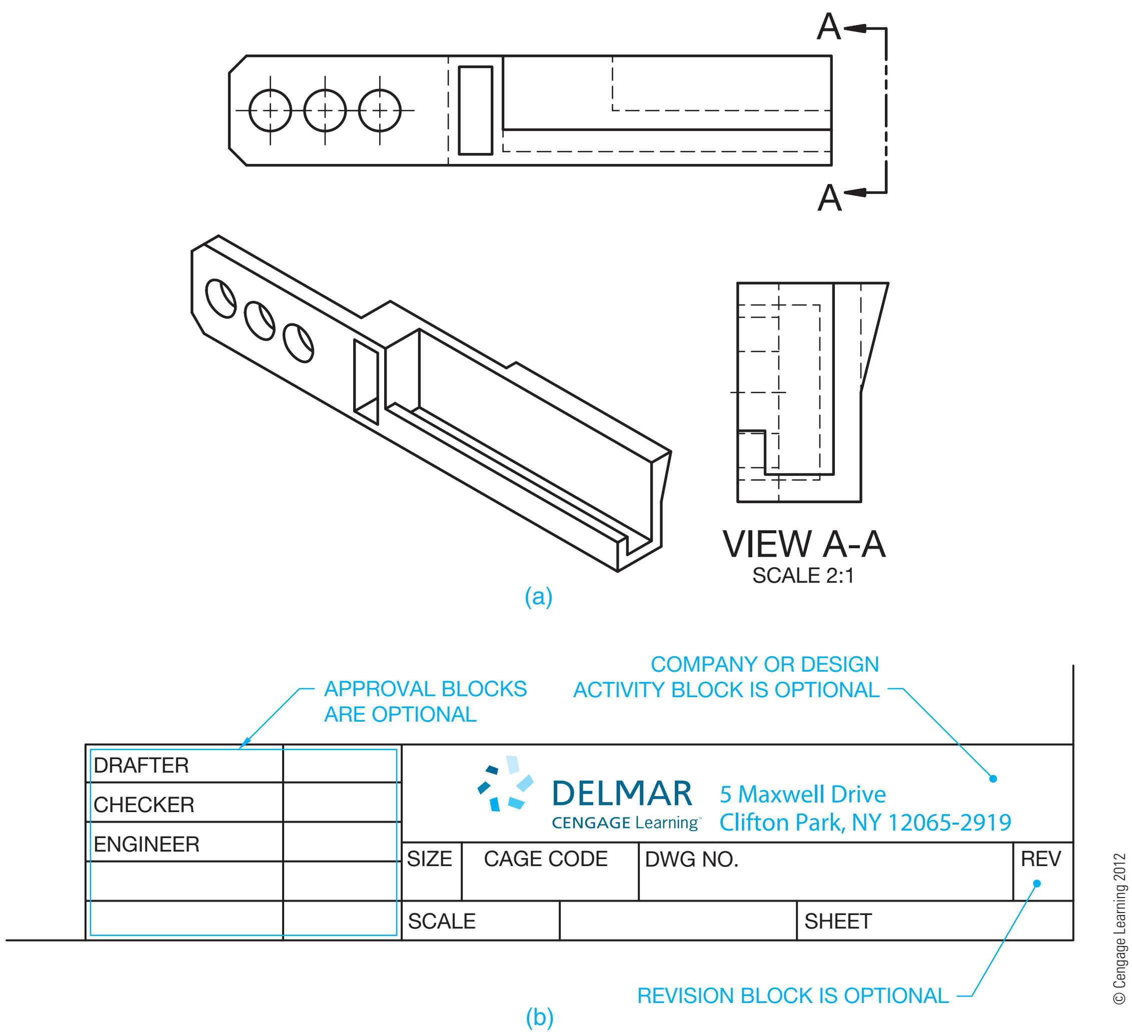

FIGURE 8.36 (a) A removed view. (b) The optional continuation title block used after the first sheet when a drawing occupies more than one sheet.

they can have a continuation sheet title block. The continuation sheet title block uses a minimum of the drawing number, scale, sheet size, CAGE code, and sheet number. Figure 8.36b shows a continuous sheet title block. Any use of this practice should be confirmed with your school or company standards.

Arrow Method for Removed Views

An alternate practice for providing removed views is called the **reference arrow method**. This method was introduced into ASME Y14.3 by the ISO. This technique uses a single reference arrow and view letter pointing to the view where the removed view is taken. The view is then moved to a desired location on the drawing and a title is placed above the view to correspond with its viewing arrow label, such as A. The removed view is kept in the same alignment as its normal arrangement. The removed view can be kept at the same scale as the other views or it can be enlarged. When the view is enlarged, the scale is placed under the view title. Figure 8.37 shows the removed view, reference arrow method, and a detail of the view arrow.

Views with Related Parts

Normally, a single part in an assembly is drawn alone on one sheet without any portion of the assembly shown. In some applications, it is necessary to show a part or parts that are next to the part being detailed. This is the related part method. When this is necessary, the adjacent part is drawn using phantom lines to show its relationship with the part being detailed as shown in Figure 8.38. This practice is usually done when there is a

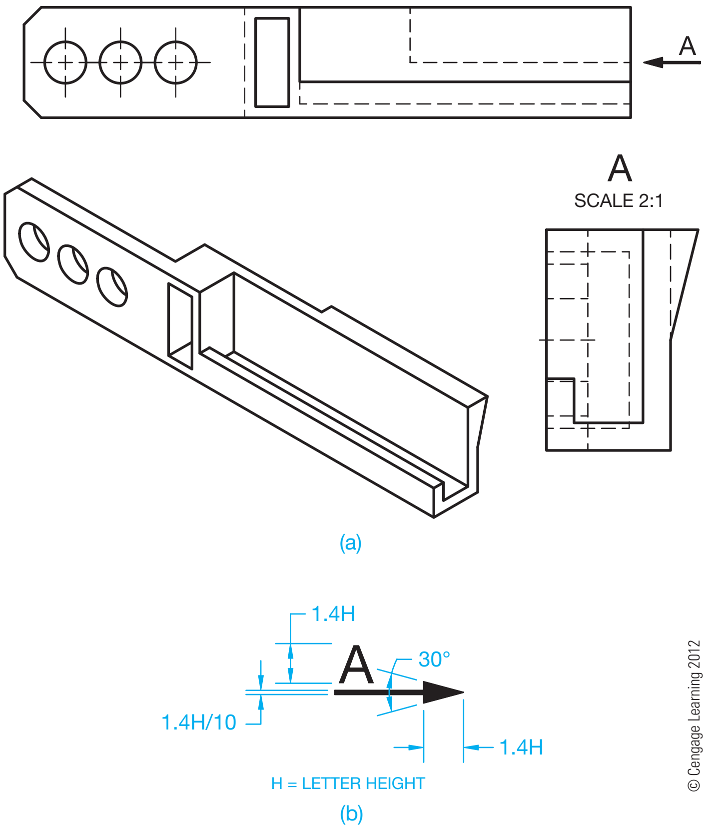

FIGURE 8.37 (a) A removed view drawing using the reference arrow method. (b) The view arrow detailed for use on your drawings.

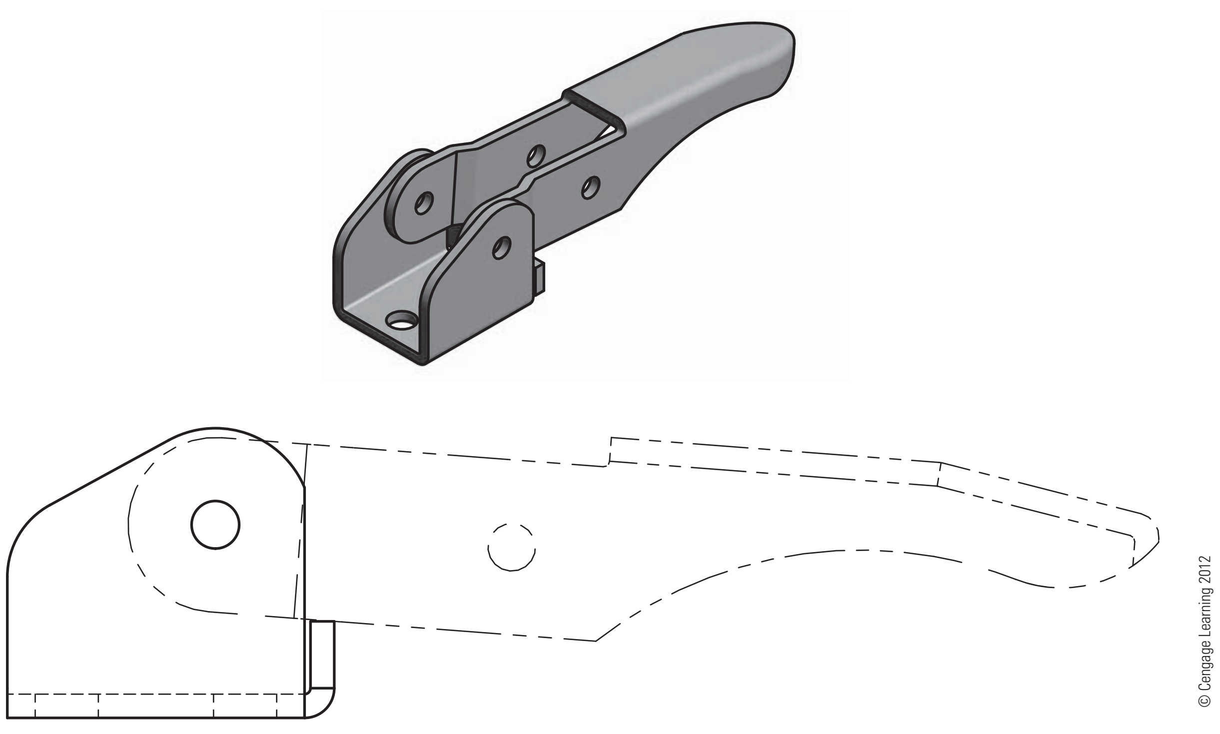

FIGURE 8.38 Phantom lines used to represent related parts.

functional relationship between the parts that needs to be specified in a note.

Rotated Views

Rotating views from their normal alignment with the six principal views should be avoided, but it is possible if necessary. Situations such as limited sheet space, view size, or an effort to keep all views on one sheet can contribute to this possibility. If this is done, you need to give the angle and direction of rotation under the view title, such as ROTATED 90° CW. CW is the abbreviation for clockwise, and CCW is the abbreviation for counterclockwise. This practice is more appropriate for use with auxiliary views than with the six principal views described in this chapter. Chapter 9 explains auxiliary views and provides additional information about using rotated views. Any use of this practice should be confirmed with your school or company standards. When sheet space is limited, it is normally best to use a larger sheet if allowed by your school or company.

PROJECTION OF CONTOURS, CIRCLES, AND ARCS

Some views do not clearly identify the shape of certain contours. In these situations, you must draw the adjacent views to visualize the contour. For example, in Figure 8.39 the true contour of the slanted surface is seen as an edge in the front view and shows the surface as an angle. The same surface is foreshortened, slanting away from your line of sight, in the right-side view. It would be impossible to know the true geometry without seeing both views. In Figure 8.40, select the front view that properly describes the given right-side view. All three front views in Figure 8.40 could be correct. The side view does not help the shape description of the front view contour.

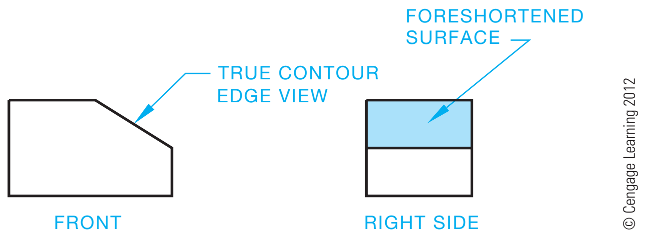

FIGURE 8.39 Contour representation. The slanted surface is a true edge in the front view and a foreshortened surface in the right-side view.

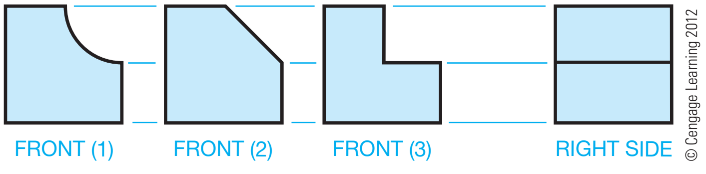

FIGURE 8.40 Select the front view that properly goes with the given right-side view. *Answer*: All three front view options are possible solutions for the given right side view.

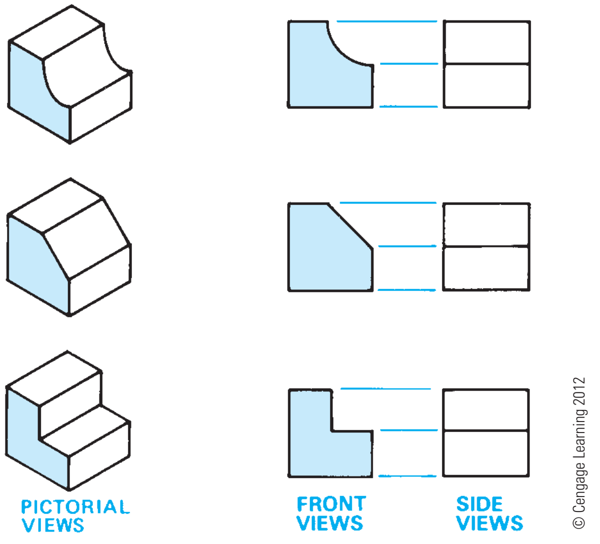

FIGURE 8.41 This shows the importance of a view that clearly shows the contour of a surface.

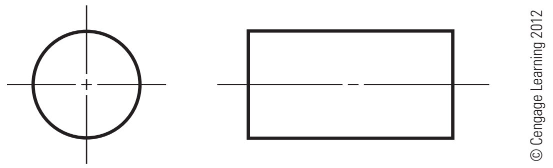

FIGURE 8.42 Cylindrical shape representation using two views.

Figure 8.41 shows another set of examples that demonstrate the importance of having at least two views to describe the true geometry of the part or object.

Cylindrical shapes appear round in one view and rectangular in another view as seen in Figure 8.42. Both views in Figure 8.42 may be necessary, because one shows the diameter shape and the other shows the length. Dimensioning practices can be used to show the object in Figure 8.42 in one view, but two views are necessary without dimensions. The ability to visualize from one view to the next is a critical skill for a drafter. You may have to train yourself to look at 2-D objects and picture 3-D shapes. You can also use some of the techniques discussed here to visualize features from one view to another.

Chamfers

A chamfer is the cutting away of the sharp external or internal corner of an edge. Chamfers are used as a slight angle to relieve a sharp edge or to assist the entry of a pin or thread into the mating feature. A chamfer is an inclined surface and is shown as a slanted edge or a line, depending on the view. The size and shape of a chamfer is projected onto views. Figure 8.43 shows three examples of chamfered features. Notice how the true contour of the slanted surfaces is seen as edges in the front views, which describe the chamfers as angles. The surfaces shown in the top view of example (a) and the right-side views

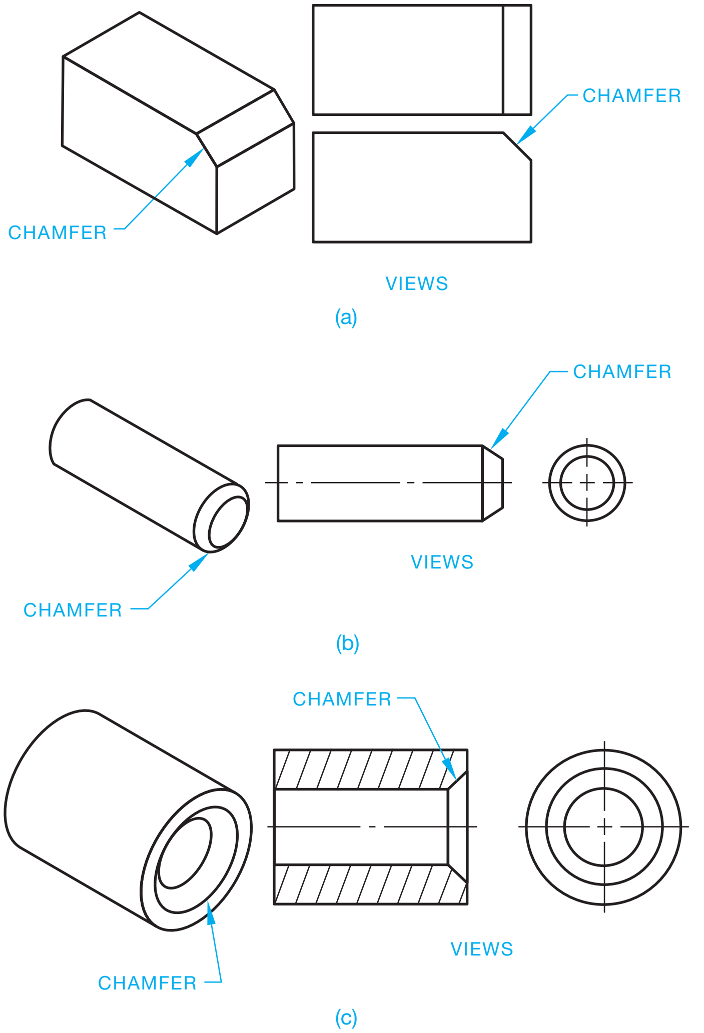

FIGURE 8.43 Chamfer examples. (a) Outside corner chamfer. (b) Chamfer of an external cylinder. (c) Chamfer on a hole.
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of examples (b) and (c) are foreshortened and slant away from your line of sight.

Circles on Inclined Planes

When the line of sight in multiviews is perpendicular to a circular feature such as a hole, the feature appears round as shown in Figure 8.44. When a circle is projected onto an inclined surface, its view is elliptical in shape, as shown in Figure 8.45. The ellipse shown in the top and right-side views of Figure 8.45 is established by projecting the major diameter from the top to the side view and the minor diameter to both views from the front view, as shown in Figure 8.46. The major diameter in this example is the hole diameter. The rectangular areas projected from the two diameters in the top and right-side views of Figure 8.46 provide the boundaries of the ellipse to be drawn in these views. The easiest method of drawing the ellipse is to use a command that allows you to specify the major and minor diameters of the ellipse followed by selecting the center point. The use of CADD makes it easy to draw ellipses with object or hidden line styles.

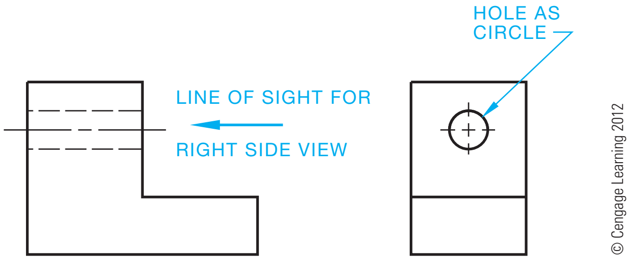


FIGURE 8.44 View of a hole projected as a circle and its hidden view through the part.

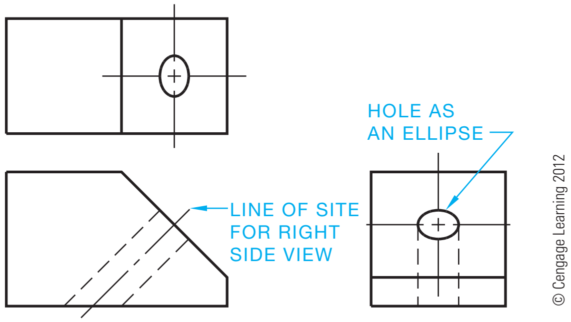


FIGURE 8.45 Hole projected from an inclined surface is represented as an ellipse in the adjacent view.

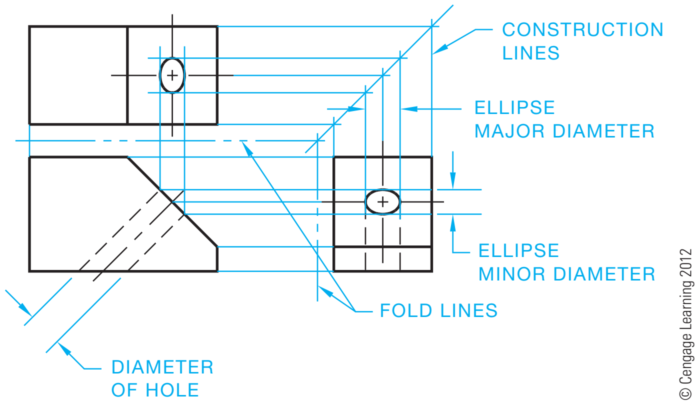


FIGURE 8.46 Establish an ellipse in the inclined surface.

Arcs on Inclined Planes

When a curved surface from an inclined plane must be drawn in multiview, a series of points on the curve establishes the contour. Begin by selecting a series of points on the curved contour as shown in the right-side view of Figure 8.47. Project these points from the right side to the inclined front view. From the point of intersection on the inclined surface in the front view, project lines to the top view. Then project corresponding points from the right side to the 45° projection line and onto the top view. Corresponding lines create a pattern of points, as shown in the top view in Figure 8.47. After the series of points is located in relationship to the front and top views, connect the points with an

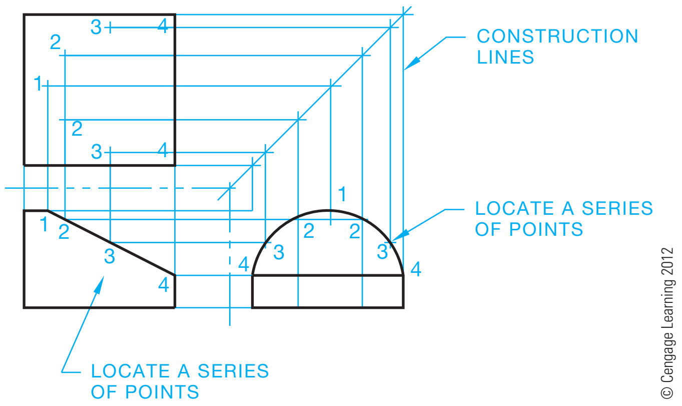


FIGURE 8.47 Locating an inclined curve in multiview.

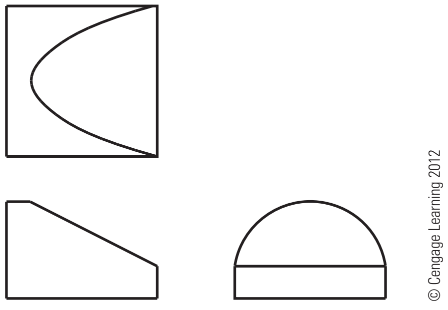


FIGURE 8.48 Completed curve.

appropriate command such as SPLINE. See the completed curve in Figure 8.48. Use a construction layer to draw the projection lines. This layer can be turned off or frozen when finished.

Fillets and Rounds

Fillets are slightly rounded inside curves at corners, generally used to ease the machining of inside corners or to allow patterns to release more easily from castings and forgings. Fillets can also be designed into a part to allow additional material on inside corners for stress relief (see Figure 8.49).

Other than the concern of stress factors on parts, certain casting methods require that inside corners have fillets. The size of the fillet often depends on the precision of the casting method. For example, very precise casting methods can have smaller fillets than green-sand casting, where the exactness of the pattern requires large inside corners. Fillets are also common on machined parts, because it is difficult to make sharp inside corners.

Rounds are rounded outside corners that are used to relieve sharp exterior edges. Rounds are also necessary in the casting and forging process for the same reasons as fillets. Figure 8.50 shows rounds represented in views.

A machined edge causes sharp corners, which can be desired in some situations. However, if these sharp corners are to be rounded, the extent of roundness depends on the function of the part. When a sharp corner has only a slight relief, it is referred to as a break corner, as shown in Figure 8.51.

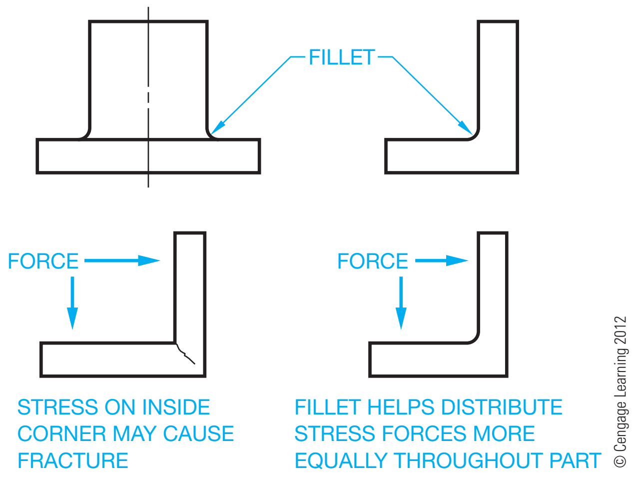


FIGURE 8.49 Fillets.

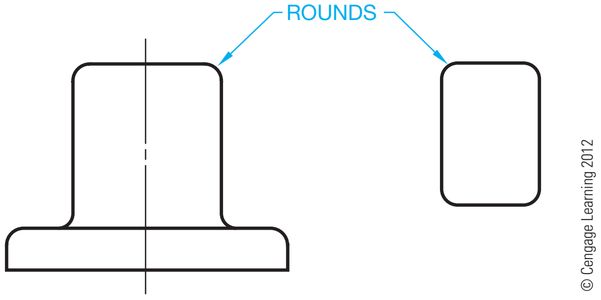


FIGURE 8.50 Rounds.

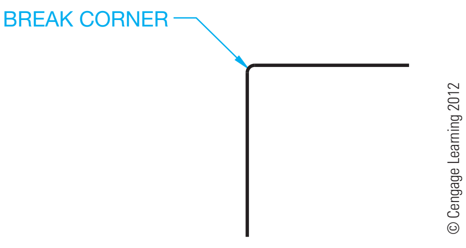


FIGURE 8.51 Break corner.

Rounded Corners in Multiview

An outside or inside slightly rounded corner of an object is represented in multiview as a contour only. The extent of the round or fillet is not projected into the view as shown in Figure 8.52. Cylindrical shapes can be represented with a front and top view, where the front identifies the height and the top shows the diameter. Figure 8.53 shows how these cylindrical shapes are represented in multiview. Figure 8.54 shows the representation of the contour of an object as typically displayed in multiview using phantom lines. This is done to accent the rounded feature.

Runouts

The intersections of features with circular objects are projected in multiview to the extent where one shape runs into the other.

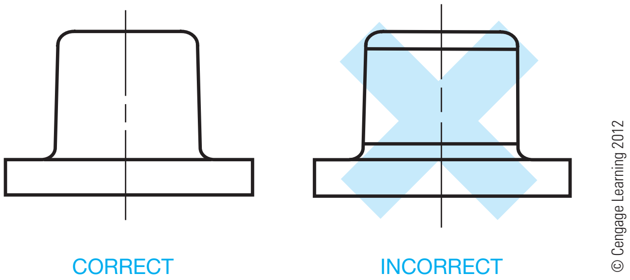


FIGURE 8.52 Rounds and fillets in multiview.

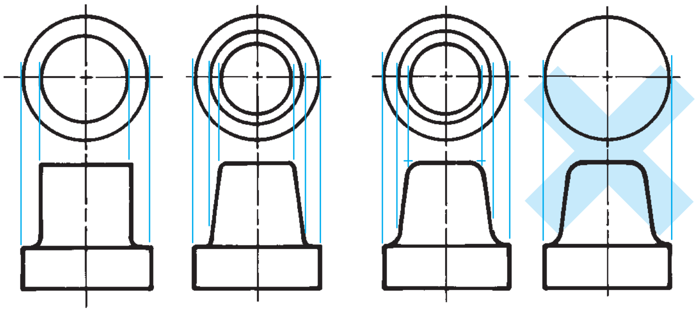


FIGURE 8.53 Rounded curves and cylindrical shape in multiview. *© Cengage Learning 2012*

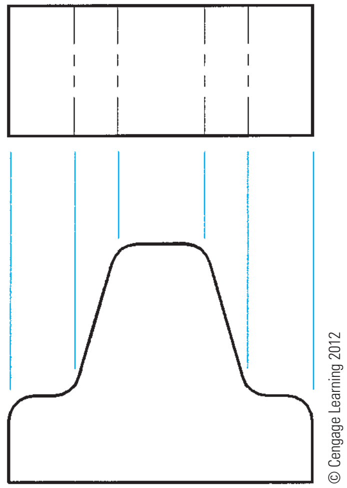


FIGURE 8.54 Contour in multiview.

The characteristics of the intersecting features are known as **runouts**. The runout of features intersecting cylindrical shapes is projected from the point of tangency of the intersecting feature, as shown in Figure 8.55. Notice also that the shape of the runout varies when drawn at the cylinder, depending on the

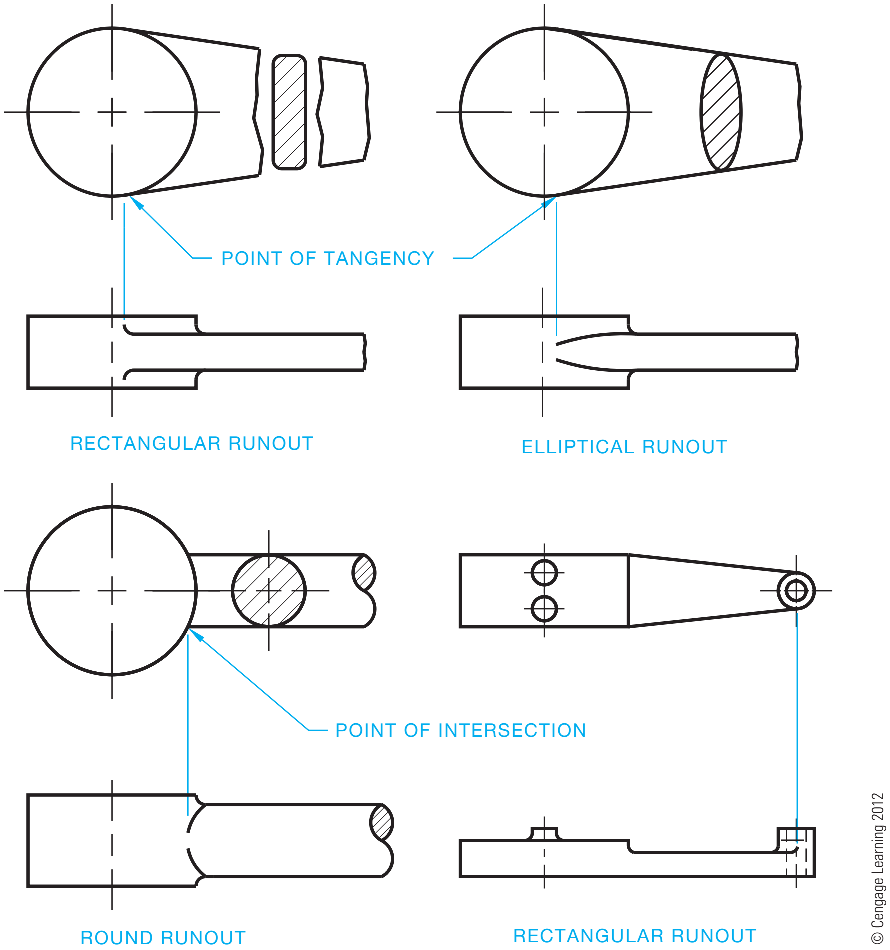


FIGURE 8.55 Establishing projections for runouts.

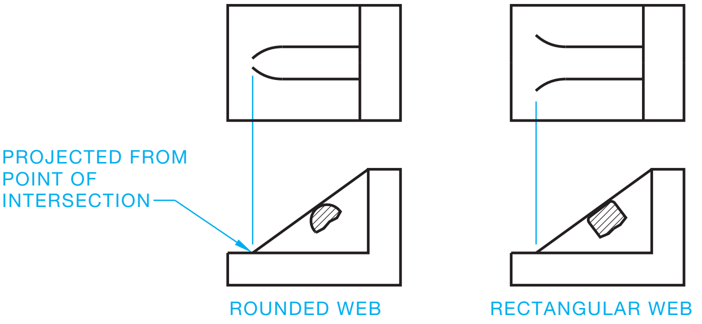


FIGURE 8.56 Projecting the runouts of a web. © *Cengage Learning 2012*

shape of the intersecting feature. Rectangular-shaped features have a fillet at the runout, whereas curved (elliptical or round) features contour toward the centerline at the runout. Runouts also exist when a feature such as a web with rounds intersects another feature, as shown in Figure 8.56.

LINE PRECEDENCE

When drawing multiviews, it is common for one type of line to fall in the same place as a different line type. As a drafter, you need to decide which line to draw and which line to omit. This is known as **line precedence**. You draw the line that is most important based on the following rules and as shown in Figure 8.57:

- Object lines take precedence over hidden lines and centerlines.
- Hidden lines take precedence over centerlines.
- In sectioning (covered in Chapter 12), cutting-plane lines take precedence over centerlines.

When an object line is drawn over a centerline, the ends or tails of the centerline are drawn slightly beyond the outside of the view or feature. Use a uniform distance, such as .125 in. (3 mm) or .25 in. (6 mm), past an object. The distance the centerline goes past the object depends on the size of the drawing and company standards. The uniform distance past an object is maintained unless a longer distance is needed for dimensioning purposes.

When a centerline is used to establish a dimension, the centerline continues as an extension line without a gap where the centerline ends and the extension line begins. This is discussed in detail in Chapter 10. Centerlines do not extend between views of the drawing except as discussed with auxiliary views in Chapter 9. Figure 8.57 shows examples of line precedence.

MULTIVIEW ANALYSIS AND REVIEW

The following is a review covering the features and importance of using multiviews and orthographic projection.

- The multiview system of orthographic projection is covered in the ASME Y14.3 standard.
- The two internationally accepted view projection systems are third-angle and first-angle projection. Both systems are discussed in this chapter, and third-angle projection is used throughout this textbook.
- Multiview drawings represent the shape of an object using two or more views; however, one view can be used when a third dimension such as depth, thickness, or diameter can be given in a note or as a dimension on the object.
- There are six principal views: front, top, right side, left side, bottom, and rear.
- All views are aligned in either third-angle projection or first-angle projection, and the appropriate third- or first-angle projection symbol should be placed on the drawing.
- Adjacent views must be aligned unless otherwise specified. **Adjacent views** are two adjoining views aligned by projection.
- Related views must be aligned unless otherwise specified. **Related views** are two views adjacent to the same intermediate view.
- There is always one dimension that is the same between views.

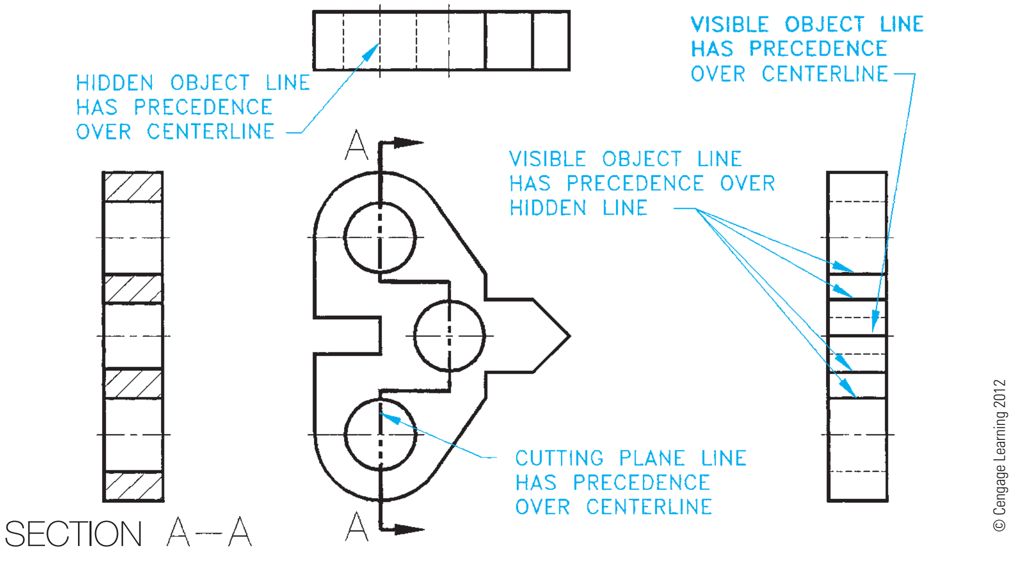


FIGURE 8.57 Line precedence.

- The front view is normally considered the most important view from which other views are established. Specific view selection guidelines are provided in this chapter.
- The number of required views can vary, depending on the complexity of the object and must be selected to describe the shape of the object and features on the object completely.
- A line in a view is in true length when the line is parallel to the projection plane.
- A surface of a view is in true size and shape when the surface is parallel to the projection plane.
- A line in a view is foreshortened when the line is not parallel to the projection plane.
- A surface of a view is foreshortened when the surface is not parallel to the projection plane.
- Additional view-placement options are discussed in this chapter and include removed views, rotated views, and detail views. Use of these options should be carefully confirmed with your school or company practices.

RECOMMENDED REVIEW

It is recommended that you review the following parts of Chapter 6, *Lines and Lettering*, before you begin working on multiview drawings. This will refresh your memory about how related lines are properly drawn.

- Object lines.
- Viewing and cutting planes.
- Hidden lines.
- Break lines.
- Centerlines.
- Phantom lines.

Descriptive Geometry

Descriptive geometry is a drafting method used to study 3-D geometry with 2-D drafting applications where planes of projections analyze and describe the true geometric characteristics.

Descriptive Geometry

For complete information about Descriptive Geometry, go to the Student CD, select **Reference Material**, and then **Descriptive Geometry I** and **Descriptive Geometry II**.

MULTIVIEW LAYOUT

Many factors influence the drawing layout. Your prime goal should be a clear and easy-to-read drawing with selected views and related information. Although this chapter deals with multiview presentation, it is not very realistic to consider view layout without thinking about the effects of dimension placement on the total drawing. Chapter 10, *Dimensioning and Tolerancing*, correlates the multiview drawings of **shape description** with dimensioning, known as **size description**.

CADD APPLICATIONS 2-D

MULTIVIEW CONSTRUCTION

Most CADD programs contain a variety of tools and options that allow you to develop multiview drawings efficiently and accurately. Construct a multiview drawing using a variety of techniques, depending on the objects needed, personal working preference, and whatever you know about the size and shape of objects. Often a combination of construction methods and CADD tools prove most effective to produce multiviews. Most 2-D drafting applications include functions for accurately defining object points using coordinate point entry methods and basic drawing aids such as grid lines and grid snaps. You can also develop multiviews using common construction geometry or specific software drawing aids such as AutoCAD's object snap and AutoTrack tools.

Construction Lines

Construction lines are widely used in CADD for layout work. Objects intended for construction purposes are usually drawn using a unique layer named Construction, for example, and assigned a specific color. You can draw construction lines using basic drafting commands such as LINE, CIRCLE, and ARC, but there are also specific tools that improve the usefulness of construction lines. One example is AutoCAD's Construction Line, or XLINE, command. The XLINE command allows you to create construction lines of infinite length horizontally, vertically, at an angle, or offset from an existing line or to bisect an angle.

Figure 8.58a shows an example of using construction lines to form three views. Use the Intersection object snap mode to select the intersecting *xlines* when drawing line and arc end points and the center point of the arc. An xline is a construction line in AutoCAD that is infinite in both directions; it is often helpful for creating accurate geometry and multiviews. Notice that a single, infinitely long xline can provide construction geometry for multiple views. When you finish using construction geometry, such as when you finalize the multiview layout, freeze or turn off the Construction layer, or use a DELETE or ERASE command to remove construction objects (see Figure 8.58b).

(Continued)

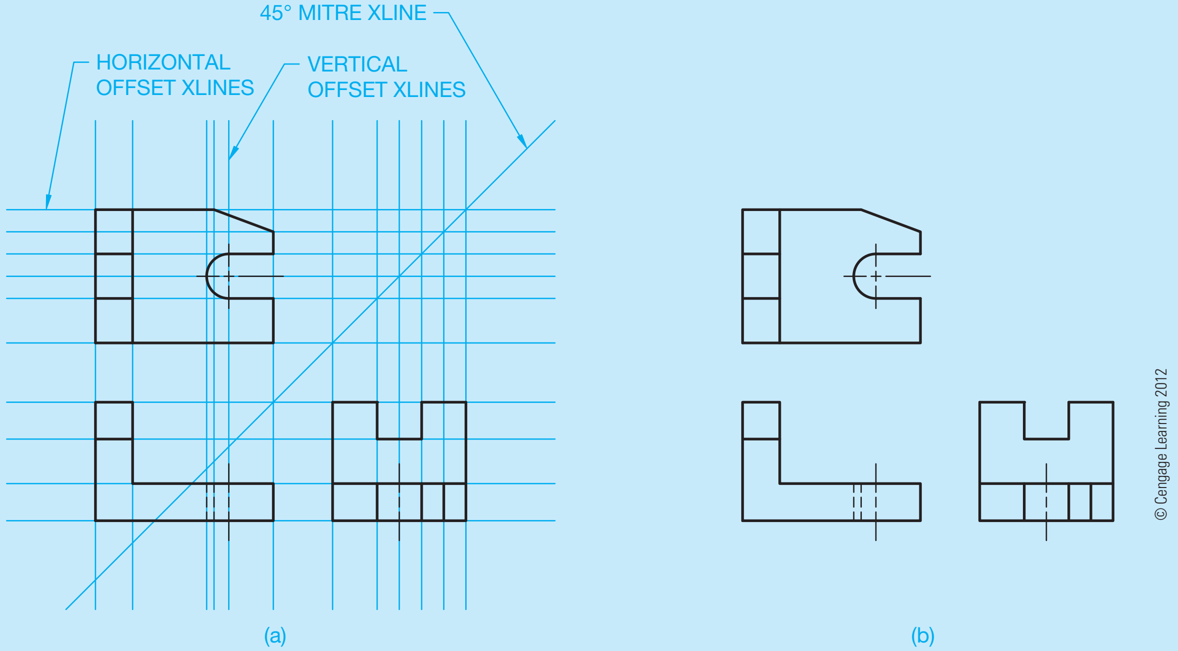


FIGURE 8.58 (a) Using a complete grid of construction lines to form a multiview drawing by locating points at the intersections of the construction lines. (b) The multiview drawing with the Construction layer turned off.

Drawing Aids

Figure 8.59 shows an example of using AutoCAD object snap tracking and a running Endpoint object snap mode to locate points for a left-side view by referencing points on the existing front view. Notice that the AutoTrack alignment path in Figure 8.59a provides a temporary construction line. AutoCAD polar tracking vectors offer a similar type of temporary construction line. Tools like object snap and polar tracking mimic accurate construction lines without the need to spend time drawing additional objects. Figure 8.59b shows the complete front and left-side views.

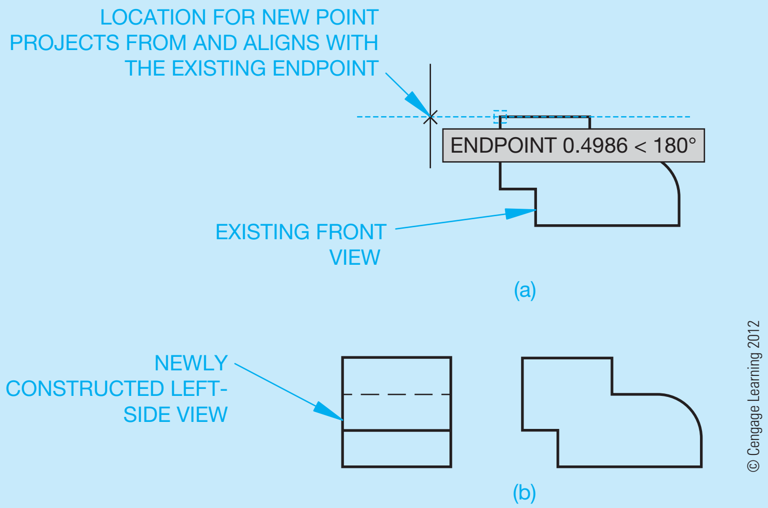


FIGURE 8.59 A basic example of using object snap tracking to create an additional view. (a) Referencing points from the front view to establish the first line of the left-side view. (b) The completed front and left-side views.

(Continued)

VIEW ENLARGEMENT

CADD software greatly improves your ability to create precise view enlargements or details. There are several possible techniques for creating enlarged views, depending on the CADD system. A basic approach is to use combinations of general editing commands, such as COPY and SCALE, to copy existing geometry to a new location and enlarge the items to any size. An often more effective method is to redisplay a portion of an existing view at a specific magnification, or zoom factor, without copying and changing the physical size of objects. One example of this process involves the use of AutoCAD's Model Space and Paper Space (Layout). With this example, you increase the displayed size of a portion of an existing view using a scaled viewport (see Figure 8.60). Working with drawing display options is an advantage because you do not have to copy and enlarge or otherwise re-create a view. Instead, you just show a portion of the view using different display characteristics.

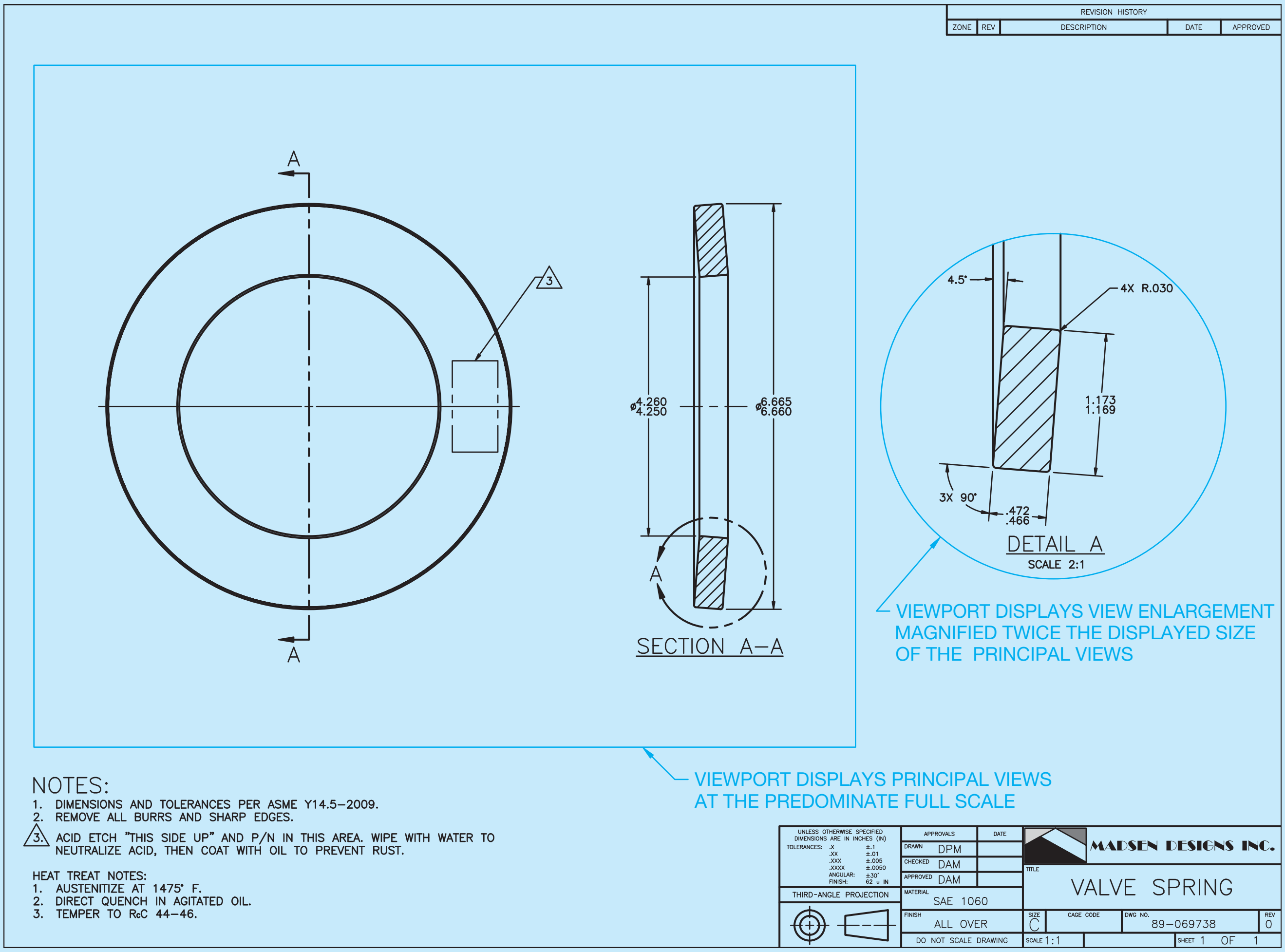


FIGURE 8.60 An example of a multiview part drawing with a view enlargement created using AutoCAD floating viewports in Paper Space (Layout). *Courtesy Madsen Designs Inc.*

MULTIVIEW PROJECTION

You can extract 2-D views from an existing 3-D model to create a multiview drawing. This approach is different from the traditional techniques of constricting multiviews, but it still follows the same multiview theory and format. A basic process is to rotate the display of the model to show orthographic views, similar to the concept of unfolding the glass box. Multiple windows or viewports, each showing a unique orthographic projection, allow you to create a multiview layout from the model. Some CADD software, primary those programs that combine 3-D solid modeling with parametric 2-D drawing capabilities, provide tools that significantly improve the basic concept of extracting multiviews from a model. Drafters new to 3-D modeling and the 2-D drawing capabilities of some modeling programs are often amazed by the speed at which entire multiview drawings can be created from an existing part or assembly model.

Preparing a multiview drawing using 3-D modeling software with 2-D drawing capabilities begins with creating the model, usually in a separate part or assembly file (see Figure 8.61a). The next step is to enter the drawing environment to extract views from the model using drawing tools. Use a tool such as BASE VIEW or MODEL VIEW to select the model from which to reference views, specify view settings, and place views. For example, assuming the model is accurate and you want to create a front view, select FRONT from a menu, specify the scale and other view characteristics, and pick a location for the view on the sheet. Now use other view tools to project additional views from the initial view as needed (see Figure 8.61).

Angle of Projection and Other View Settings

You must select the appropriate angle of projection and other view settings when extracting multiviews from a solid model. Figure 8.61b shows three views of a model created using third-angle projection. Figure 8.61c shows views created using first-angle projection. What you cannot see in Figure 8.61 is the mere seconds it took to create the multiviews from the existing model. Some CADD systems offer predefined view layouts that allow you to create a specific arrangement of multiviews in a single operation. You can use tools like Autodesk Inventor SHEET FORMAT or SolidWorks STANDARD 3 VIEW to create the required number of views from a model instantly.

The file you use to create multiviews from a model includes all settings and preferences, such as angle of projection, view alignment and scale, object display style, and line conventions. For example, when you select the third-angle projection setting shown in Figure 8.61b, the system automatically applies third-angle projection when you project views. The system also maintains correct alignment and settings between views. However, you are still responsible for determining the appropriate views and multiview layout. The parametric nature of solid modeling programs ensures that when you edit a model, the corresponding drawing updates to reflect the new design. Similarly, you can change a model by modifying the parametric model dimensions inside the 2-D drawing.

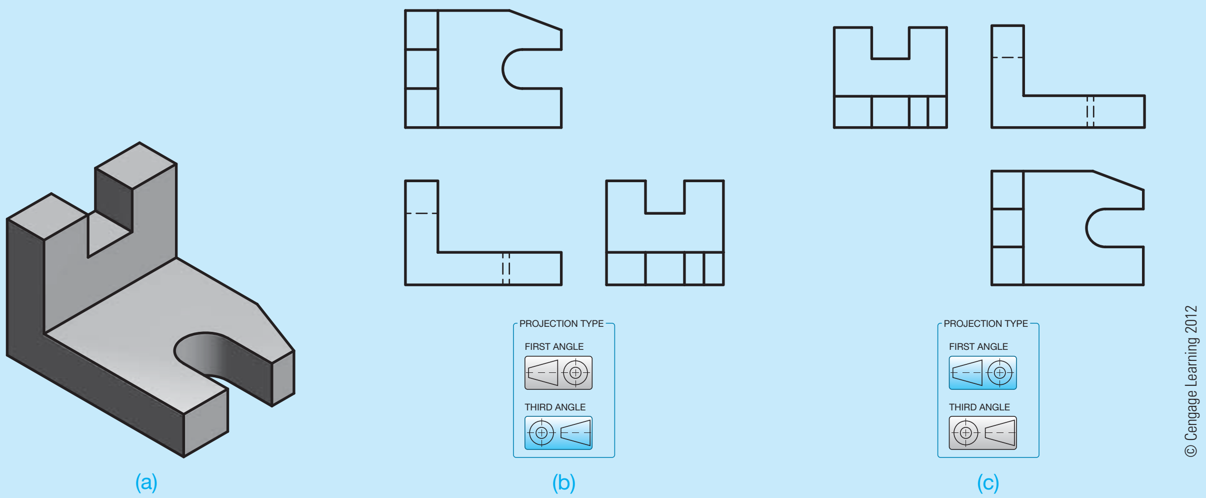


FIGURE 8.61 (a) The solid model provides all of the geometry needed to prepare a multiview drawing. (b) Using a separate drawing file and third-angle projection to extract mutliviews. (c) Using a separate drawing file and first-angle projection to extract mutliviews.

(Continued)

VIEW ENLARGEMENT

Some 3-D modeling software with 2-D drawing capabilities provide tools that make preparing accurate alternate views, such as view enlargements, fast and easy. Tools such as DETAIL VIEW allow you to create a view enlargement by referencing an existing drawing view, which parametrically associates a view with the model (see Figure 8.62). Using tools like DETAIL VIEW typically involves drawing a circle or other shape around a specific feature on an existing drawing view, such as the front view shown in Figure 8.62. You then specify view preferences, such as scale and title, and pick a location for the view on the sheet. Depending on the drawing settings, the required phantom line circle, arrowheads, identification letter, and view title automatically add to the drawing.

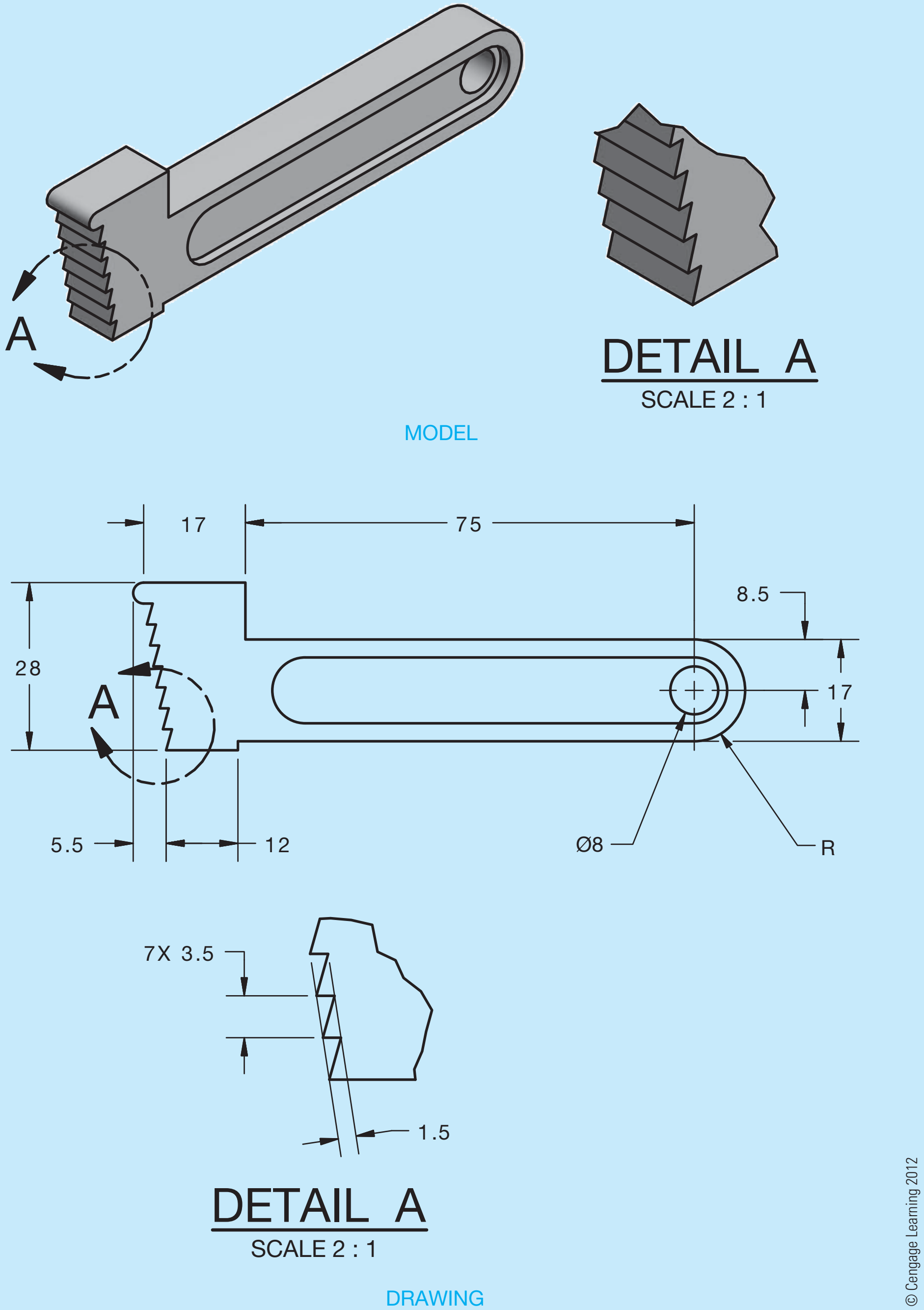


FIGURE 8.62 Tools such as DETAIL VIEW allow you to create a view enlargement by referencing an existing drawing view, which parametrically associates all views with the model.

NOTE: The following information provides very detailed steps and instructions for drawing layout. These steps were critical in the past when using manual drafting. Manual drafting requires you to determine specific views, dimension locations, drawing scale, and sheet size before starting to draw. Once you begin manual drafting, the only way to change your strategy is to erase or start over. This is not the case with CADD, although it is still important to do preliminary planning when using CADD.

Careful planning is especially useful as a student or entry-level drafter. Careful planning normally saves you time and frustration. The following steps can help you learn to think about all of the items that go into creating a drawing, including number of views, view placement, view spacing, space needed for dimensions and notes, drawing scale, and the sheet sized needed for a clear and easy-to-read final drawing. The advantage to CADD is that it is easy and accurate to fix mistakes and add content to a drawing. When using CADD, you can move views as desired, change the drawing scale or sheet size at any time, and you can add a view or detail without much difficulty. Nevertheless, before you become an experienced drafter, it is best to start out by following the logical sequence of steps described in this chapter.

Sketching the Layout

The initial steps in view layout should be performed using rough sketches. By using rough sketches, you can analyze which views you need before you begin formal drafting. Sketches do not have to be perfect. Try to sketch as quickly as you can to save time. Consider the engineering sketch in Figure 8.63 as you evaluate the proper view layout.

STEP 1 Select the front view using the rules discussed in this chapter. Sketch your selected front view. Try to keep your sketch proportional to the actual object, as in Figure 8.64. However, keep in mind that a sketch does not have to be perfect. It should be done quickly to save time while helping you lay out the drawing.

STEP 2 Select the other views needed to describe the shape of the V-BLOCK MOUNT completely, as shown in Figure 8.65.

The front, top, and left-side views clearly define the shape of the V-BLOCK MOUNT. Now lay out the formal drawing using the sketch as a guide. Several factors must be considered before you begin:

1. Size of drawing sheet.
2. Scale of the drawing.
3. Number and size of views.
4. Amount of blank space required for notes and future revisions.
5. Dimensions and notes (not drawn at this time).

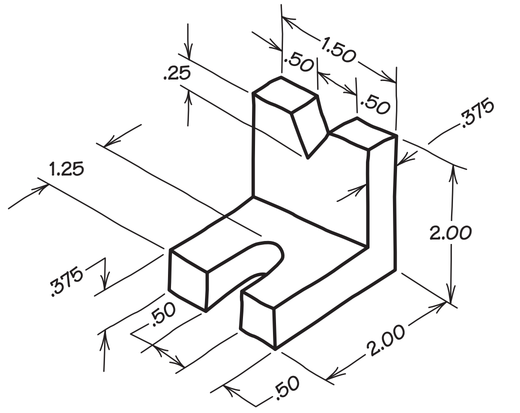


FIGURE 8.63 Create a multiview drawing from the given engineering sketch.

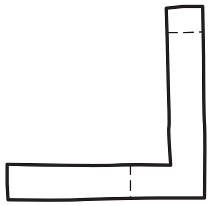


FIGURE 8.64 Sketch the front view.

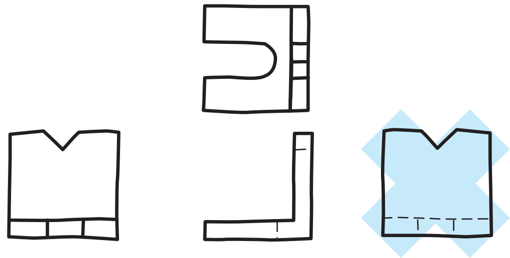


FIGURE 8.65 Sketch the required views.

Drawing the Layout

STEP 1 The recommended drawing area is determined by the sketch and calculations shown in Figure 8.66. In the example of the V-BLOCK MOUNT in Figure 8.66, there are three views, with the overall dimension of each view shown, and there is an estimated spaced provided between views. Use your rough sketch as a guide to establish the actual size of the drawing by adding the overall dimensions and the space between views. The overall drawing area is calculated to be 5.5 × 5 in. (250 × 15 mm). The amount of space selected between views should not crowd the views. The actual space between views is determined by the dimensions placed between the views. Keep in mind that you do not need to consider actual dimensions when evaluating space requirements at this time. The effect of dimensions on drawing layouts is discussed in Chapter 10.

STEP 2 After determining the approximate drawing area in Figure 8.66, determine the working area so you can establish the desired sheet size. The working area is the space available on the sheet for you to place the drawing. The

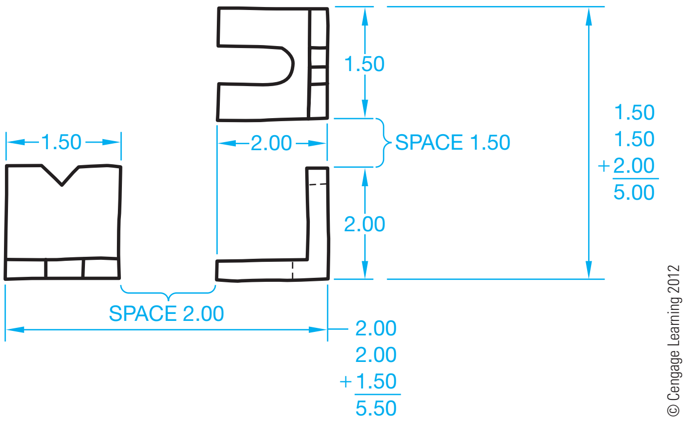


FIGURE 8.66 Rough sketch with overall dimensions and selected space between views to determine the estimated drawing area.

amount of blank area on a drawing depends on company standards. Some companies want the drawing to be easy to read and with no crowding. Other companies may want as much information as possible on the smallest sheet. Generally, .50 in. (12.7 mm) should be the minimum space between the drawing and borderlines, sheet blocks, and general notes. More space is preferred. An area for future revision should be left between the title block and upper right corner of the sheet. An area for general notes should be available to the left of the title block for ASME standard layout or in the upper left corner for military (MIL) standard layout. The remaining area is the working area, which is the space available for drawing. The working area of a B-size (11 × 17 in.) or A3-size (297 × 420 mm) drawing sheet provides enough space for the desired drawing area. Figure 8.67 shows the proposed drawing area inside of the working area of a B-size drawing sheet.

STEP 3 Within the working area and drawing area established, use construction lines to block out the views that you selected in the rough sketch. Use multiview projection as discussed in this chapter, beginning with the front view (see Figure 8.68). Place your construction lines on a unique layer that can be turned off or frozen when no longer needed.

STEP 4 Complete your drawing by using proper ASME line types and line thicknesses. Each line type should be on its own layer. The general notes can be entered in the lower left corner of the drawing by providing a .5 in. (12.7 mm) space from the border line. Placing notes is optional at this time but will be required after you learn about dimensioning practices. Confirm with your instructor if notes should be added now. Figure 8.69 shows the completed drawing.

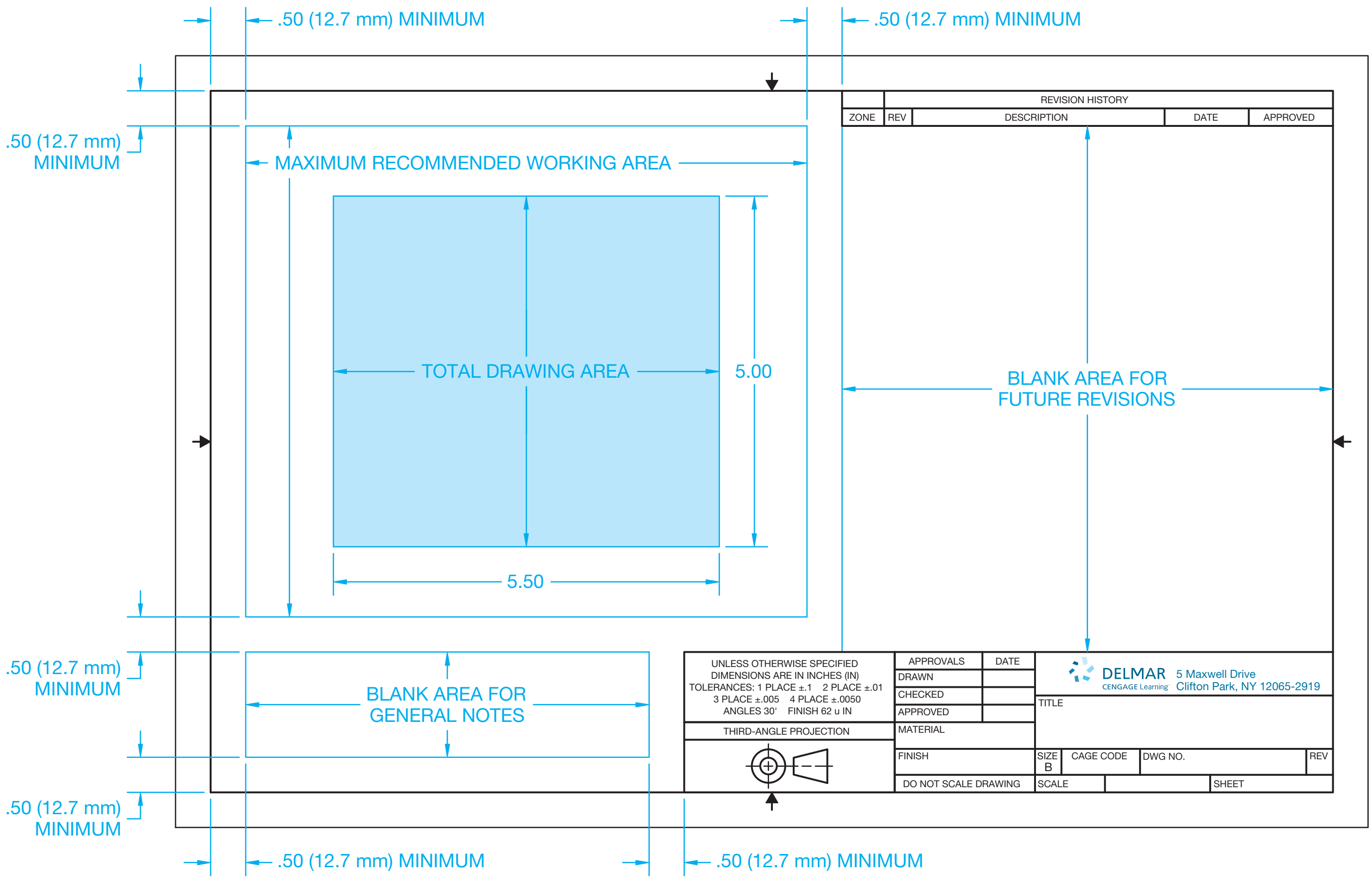


FIGURE 8.67 The recommended drawing area inside the available working area. *© Cengage Learning 2012*

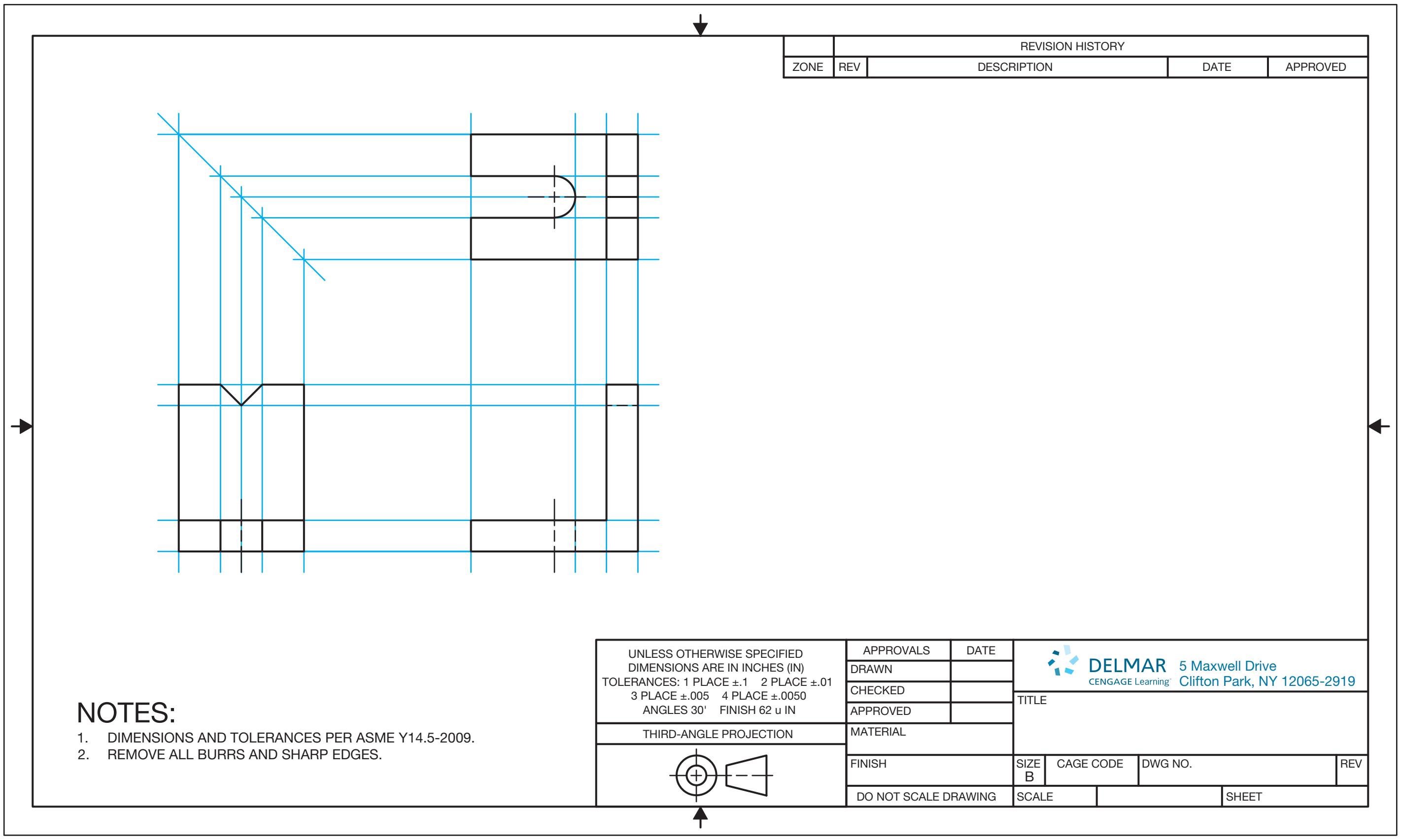


FIGURE 8.68 Lay out the views using construction lines. © *Cengage Learning 2012*

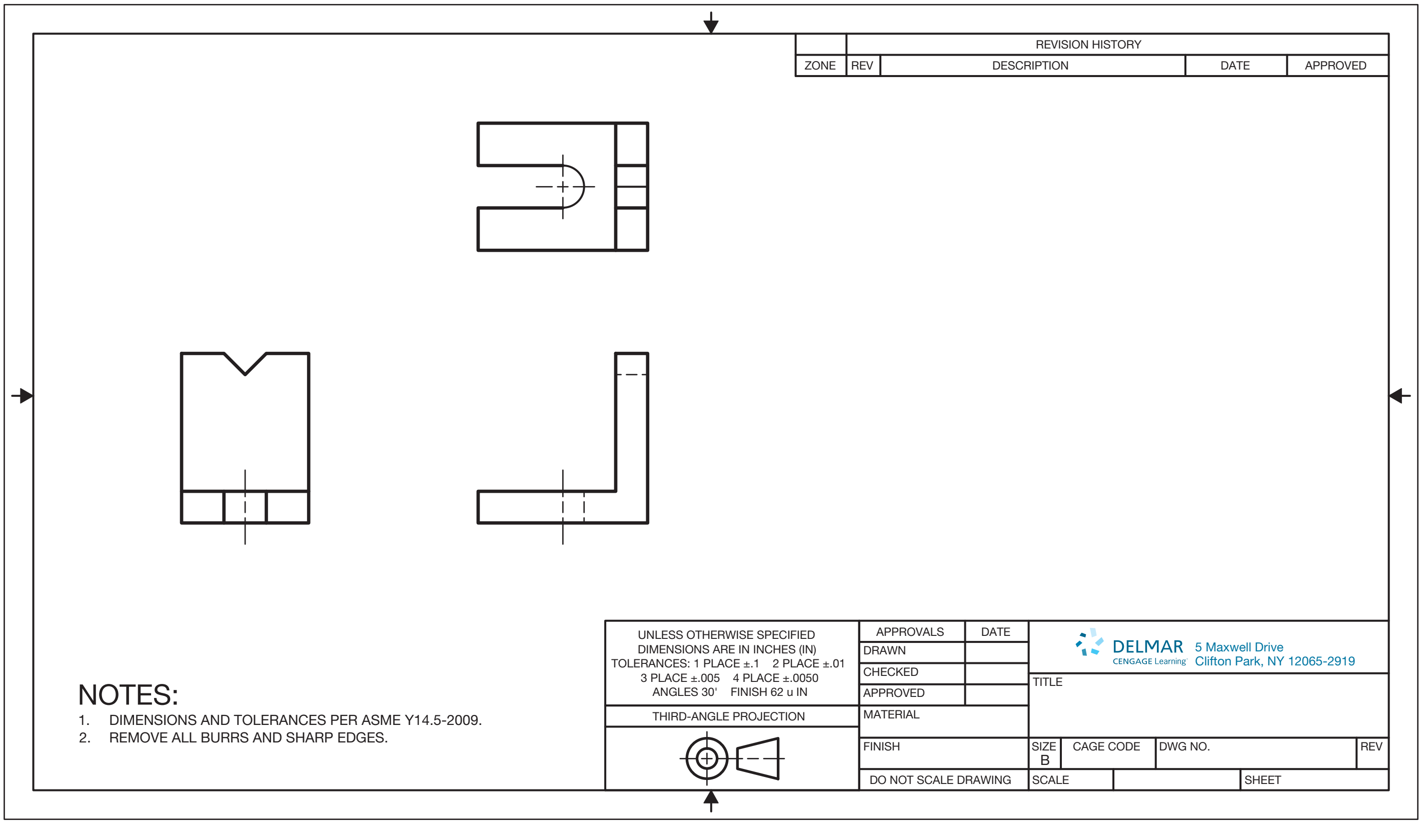


FIGURE 8.69 Completed multiview drawing without dimensions or title block content filled in. © *Cengage Learning 2012*

CADD APPLICATIONS

DRAWING LAYOUT

When setting up a CADD drawing, use a sketch to determine the total drawing area. You can then determine the sheet size and establish settings specific to the drawing, such as the working area. A major advantage to CADD is the ability to change the maximum working area of the drawing and the sheet size if you make a mistake calculating multiview layout or whenever changes require a modified layout. When using CADD, views are generally drawn full size and then scaled as needed to fit into a paper layout before plotting or printing. This concept provides accuracy and flexibility while drawing.

Use a detailed **template** whenever possible. A CADD template is a file that contains standard settings that apply to new drawings. A template can include predefined drawing layouts, borders, title blocks, and other common drafting components, features, and standards. Figure 8.70 shows a layout found in a template file, created for drawing on a B-size sheet, using ASME drafting standards.

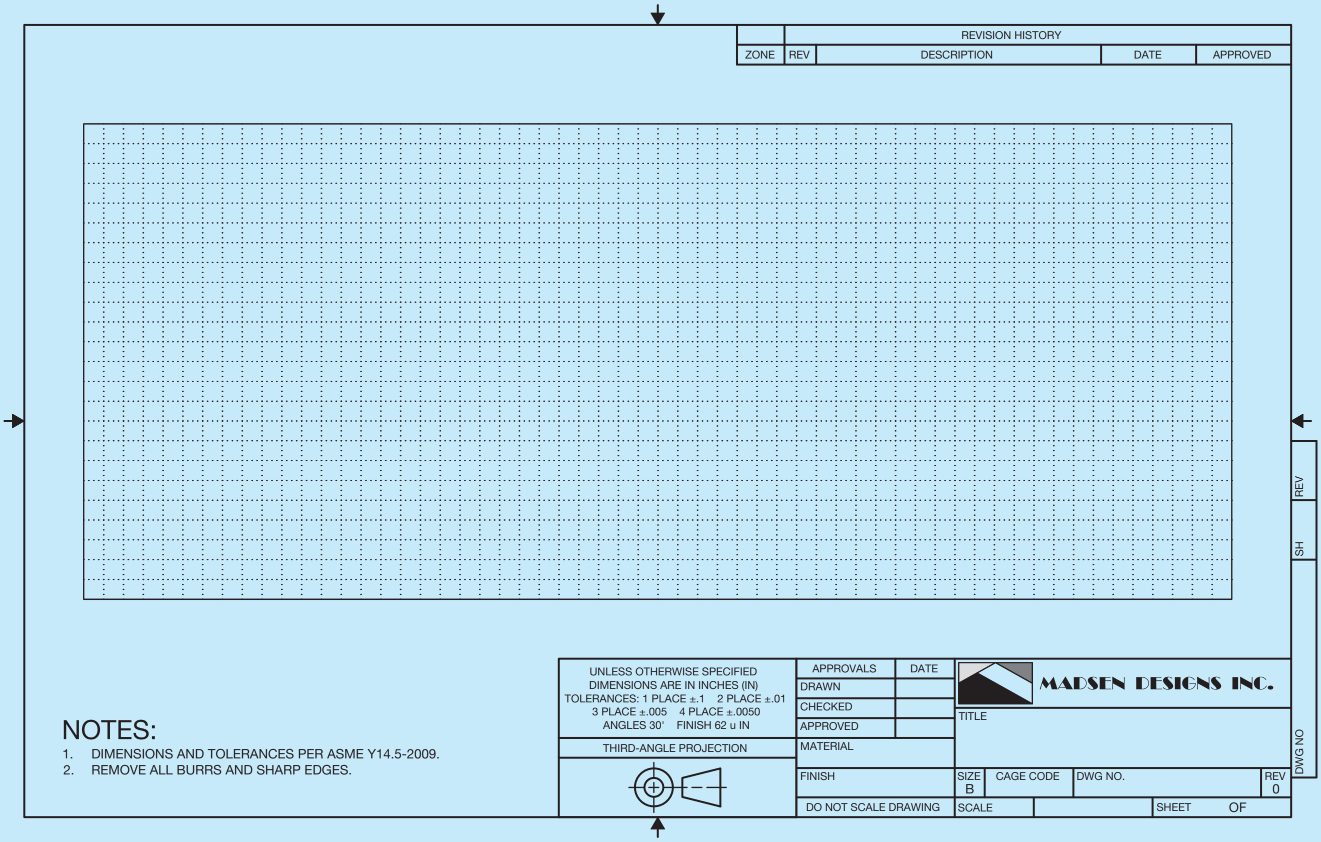


FIGURE 8.70 A CADD template with predefined settings for drawing on a B-size sheet using ASME drafting standards. *Courtesy Madsen Designs Inc.*

PROFESSIONAL PERSPECTIVE

If you follow the view selection guidelines discussed in this chapter, you should be able to handle any drafting project. Establishing and laying out the necessary views of a part can be one of the most challenging aspects of drafting. The views that you select and the way you lay out the drawing can make the difference between having a drawing that is easy to read and understand or a drawing that is confusing and difficult to read. The practice of view projection that you learned in this chapter provides you with the foundation for effectively selecting and laying out multiviews. Look at the drawing in Figure 8.71. This complex part is laid out with a number of multiviews that help the reader see every surface of the part. Become familiar with practices that are used in the industry and spend as much time as you can looking at drawings that have been created by professional drafters.

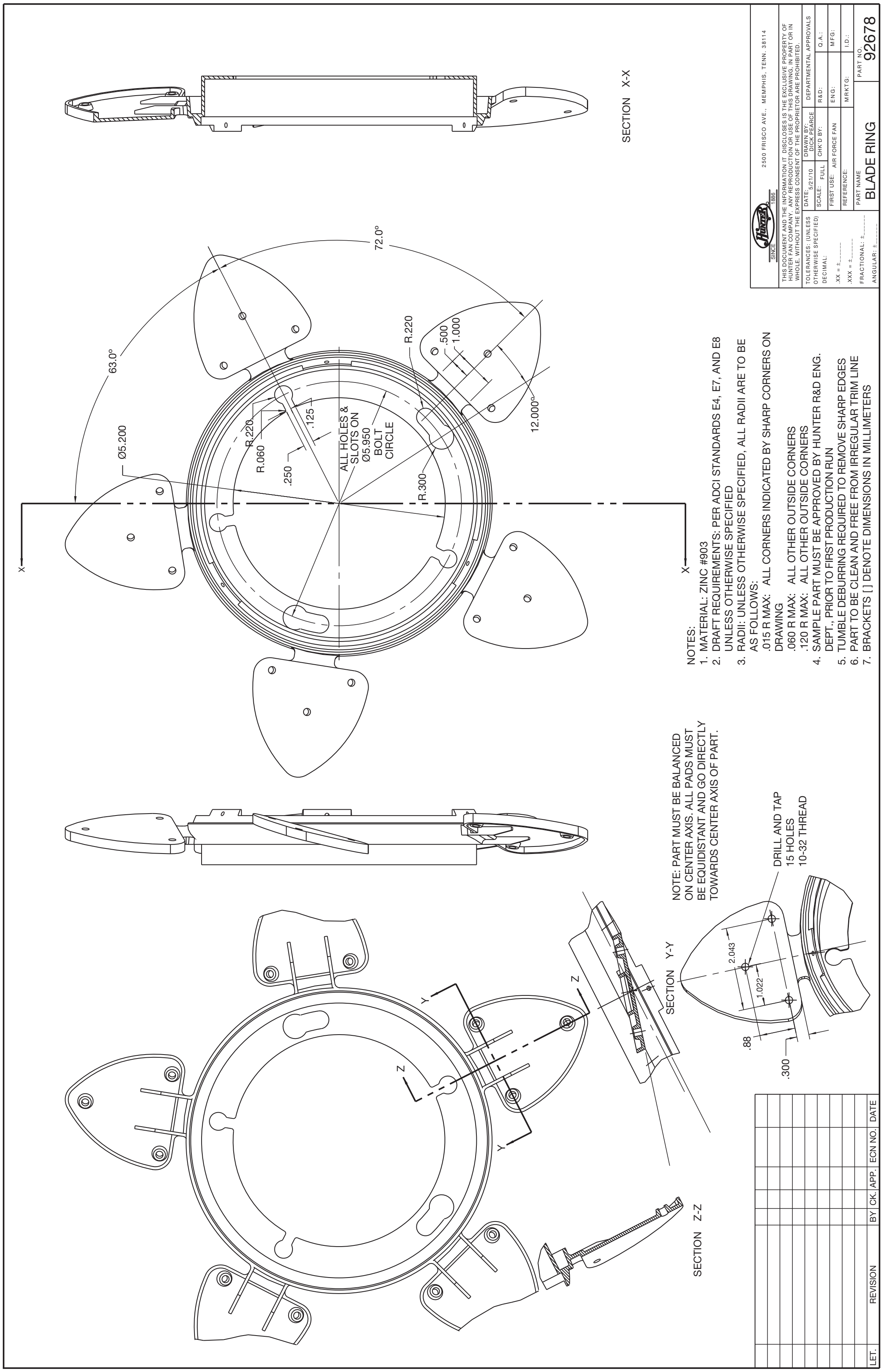


FIGURE 8.71 A complex part displayed on a drawing using several carefully selected views. *Courtesy Hunter Fan Company*

MATH APPLICATIONS

WEIGHT OF AN ELLIPTICAL PLATE

Problem: A large steel plate in the shape of an ellipse is to be moved. The plate has the dimensions shown in Figure 8.72.

The steel is known by its thickness to weigh 19 lb/ft². What is the weight of this plate?

Solution: The area of an ellipse is given by the formula, Area = $\pi \times y$, as defined by Figure 8.73.

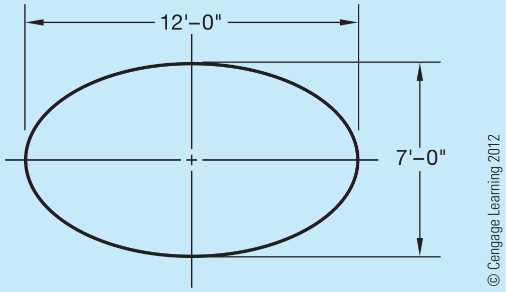


FIGURE 8.72 The major and minor diameters of the elliptical plate.

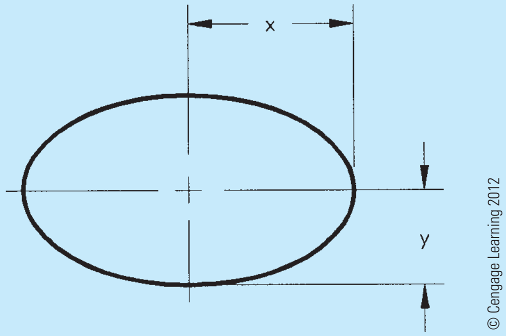


FIGURE 8.73 Ellipse.

This formula says to multiply the constant π (which is about 3.14159) by dimension x and then multiply that result by dimension y. For the steel plate, $x = 6'$ and $y = 3.5'$, so the area is (3.14159) (6) (3.5), or 65.98 square feet (ft²). Now the weight can be found:

$$65.98 \text{ ft}^2 \times 19 \text{ lb/ft}^2 = 1253 \text{ lb.}$$

WEB SITE RESEARCH

Use the following Web sites as a resource to help find more information related to engineering drawing and design and the content of this chapter.

Address	Company, Product, or Service
www.asme.org	American Society of Mechanical Engineers (ASME)
www.iso.org	International Organization for Standardization
www.adda.org	American Design Drafting Association and American Digital Design Association (ADDA International)

Chapter 8

Chapter 8 Multiviews Test

To access the Chapter 8 test, go to the Student CD, select **Chapter Tests and Problems**, and then **Chapter 8**. Answer the questions with short, complete statements, sketches, or drawings as needed. Confirm the preferred submittal process with your instructor.

Chapter 8 Multiviews Problems

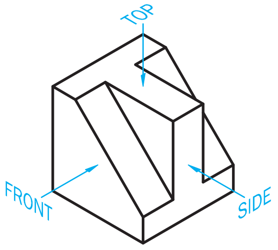
Parts 1 and 2: Problems 8.1 Through 8.45

To access the Chapter 8 problems, go to the Student CD, select **Chapter Tests and Problems** and **Chapter 8**, and then open the problem of your choice or as assigned by your instructor. Solve the problems using the instructions provided on the CD, unless otherwise specified by your instructor.

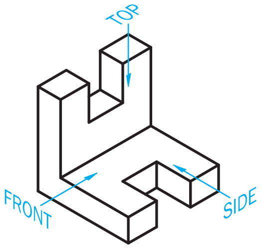
Part 3: Problems 8.46 Through 8.52

The following problems provide you with a pictorial view of an object with required views identified with arrows pointing at the viewing direction and labeled with the specific view orientation. Measure the given pictorial view and transfer your measurements to the required multiviews. Create one set of first-angle projection views and one set of third-angle projection views for each object. Label each view below the view exactly as given in the pictorial, and label each set of views as FIRST-ANGLE PROJECTION and THIRD-ANGLE PROJECTION correctly correlated to the sets of multiviews.

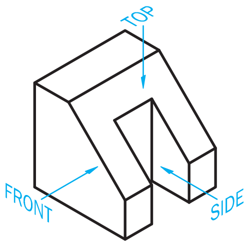
PROBLEM 8.46



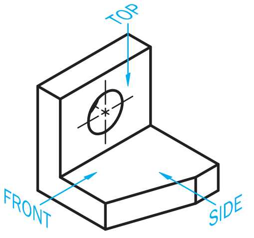
PROBLEM 8.47



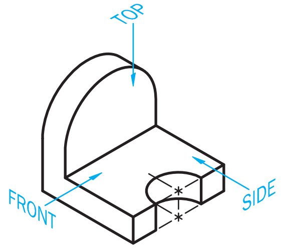
PROBLEM 8.48



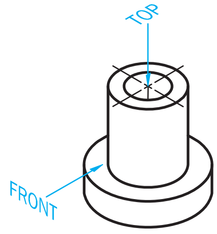
PROBLEM 8.49



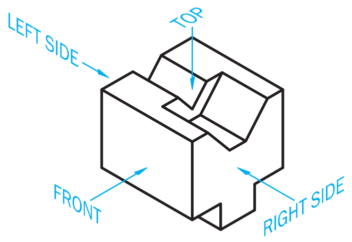
PROBLEM 8.50



PROBLEM 8.51



PROBLEM 8.52



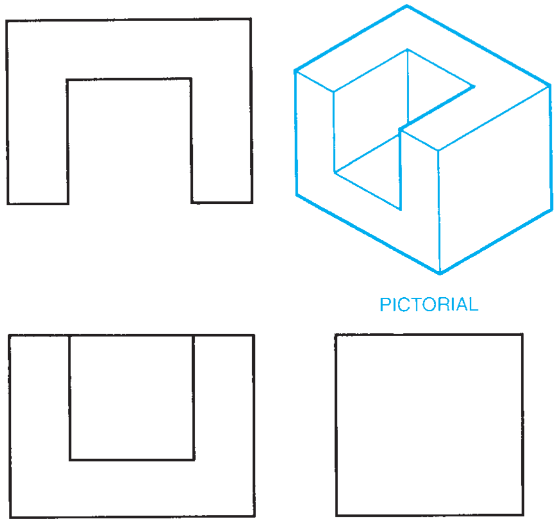
Part 4: Problems 8.53 Through 8.64

The following problems provide you with views that contain missing lines or missing views. Draw the missing lines or missing views as appropriate. Pictorial views are provided to aid in visualization. You do not need to draw the pictorial view. Measure the given views and transfer the measurements to your formal drawing. Set up your drawings with a properly sized border and title block. Use an ASME sheet and sheet blocks. Properly complete the information in the title block.

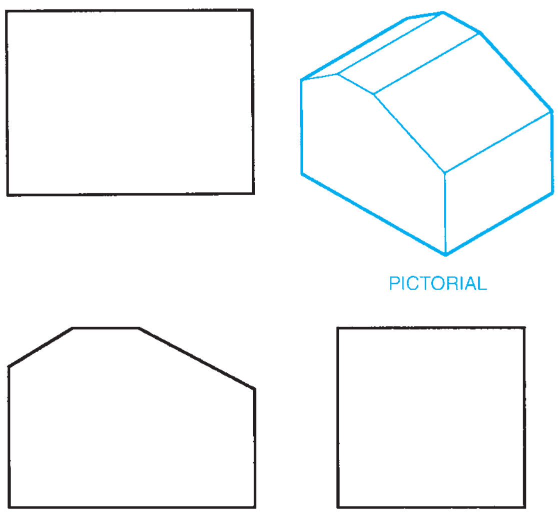
Drafting Templates

To access CADD template files with predefined drafting settings, go to the Student CD, select **Drafting Templates**, and select the appropriate template file. Use the templates to create new designs, as a resource for drawing and model content, or for inspiration when developing your own templates. The ASME-Inch and ASME-Metric drafting templates follow ASME, ISO, and related mechanical drafting standards. Drawing templates include standard sheet sizes and formats, and a variety of appropriate drawing settings and content. You can also use a utility such as the AutoCAD DesignCenter, to add content from the drawing templates to your own drawings and templates. Consult with your instructor to determine which template drawing and drawing content to use.

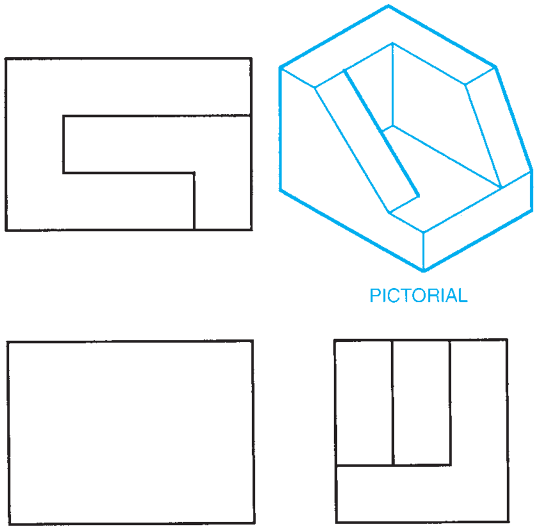
PROBLEM 8.53 **Pocket block**



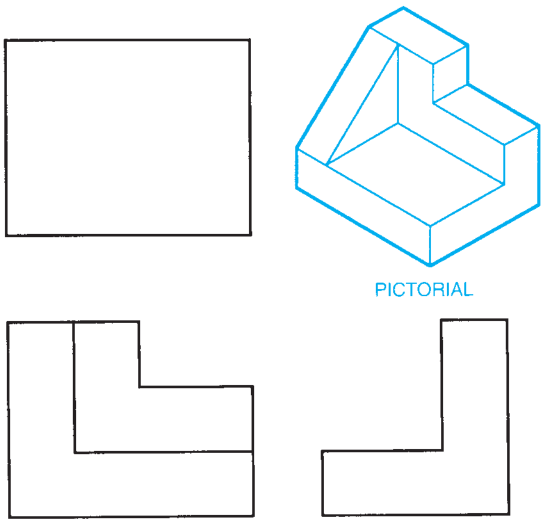
PROBLEM 8.54 **Angle gage**



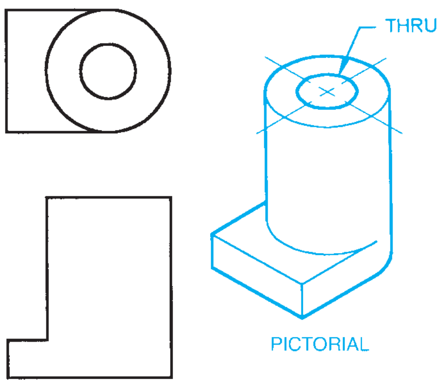
PROBLEM 8.55 **Base**



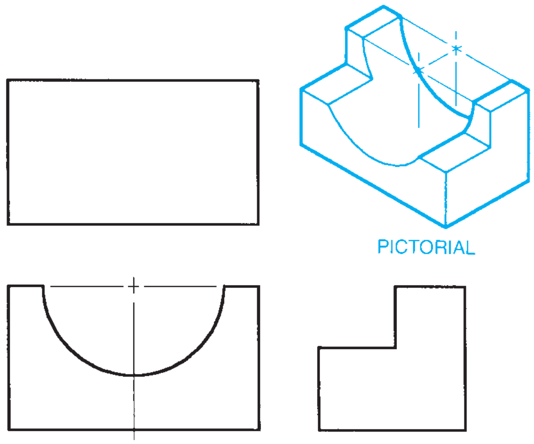
PROBLEM 8.56 **Corner block**



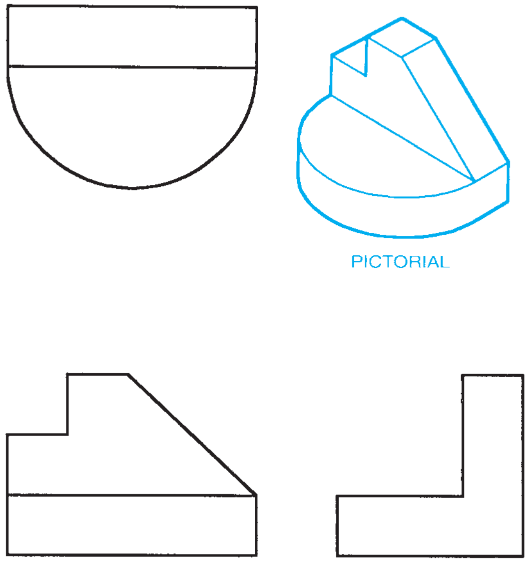
PROBLEM 8.57 **Cylinder block**



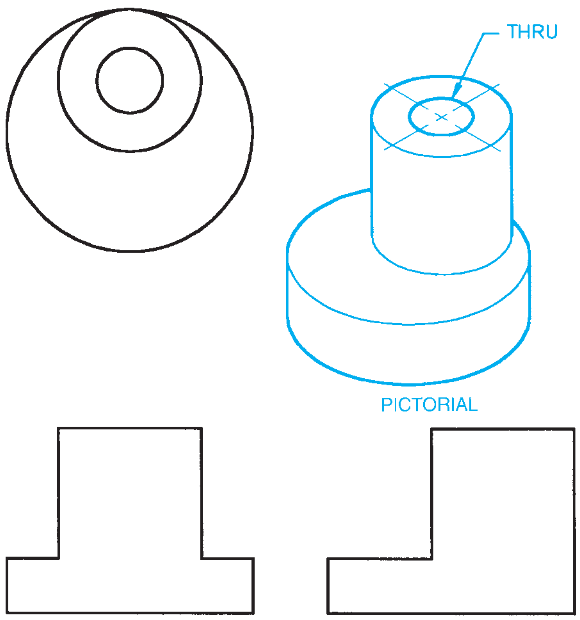
PROBLEM 8.58 **Shaft block**



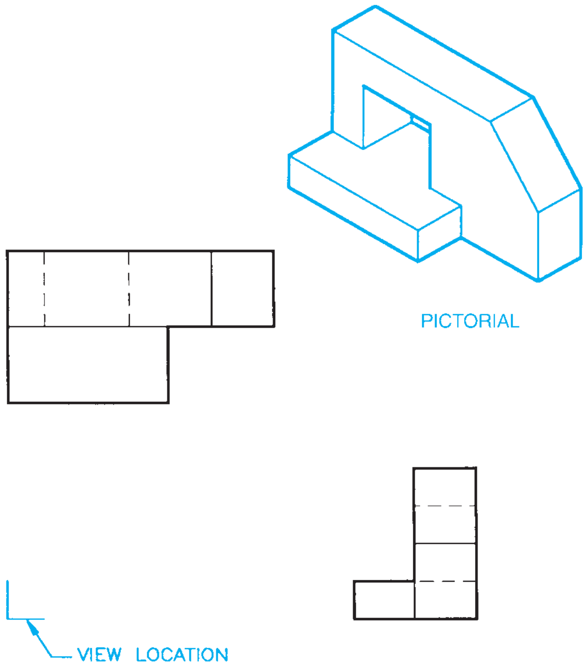
PROBLEM 8.59 **Gib**



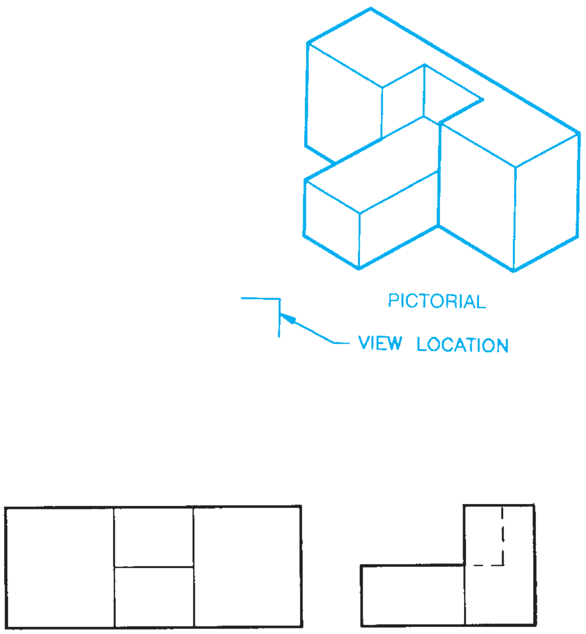
PROBLEM 8.60 **Eccentric**



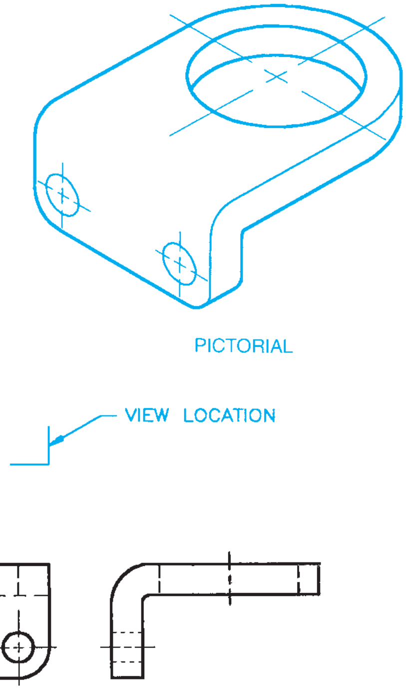
PROBLEM 8.61 Guide block



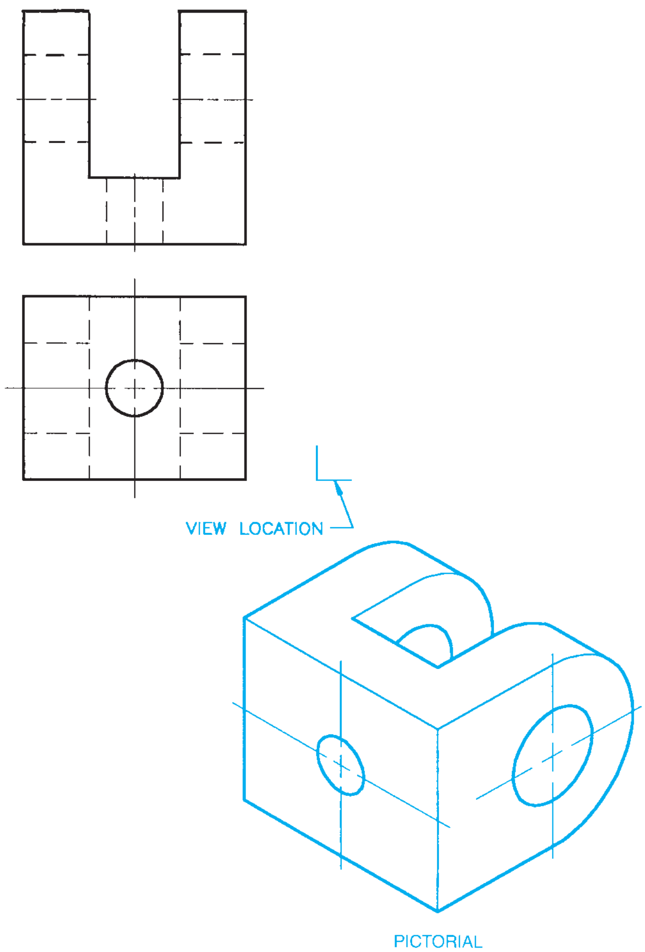
PROBLEM 8.62 Key slide



PROBLEM 8.63 Angle bracket



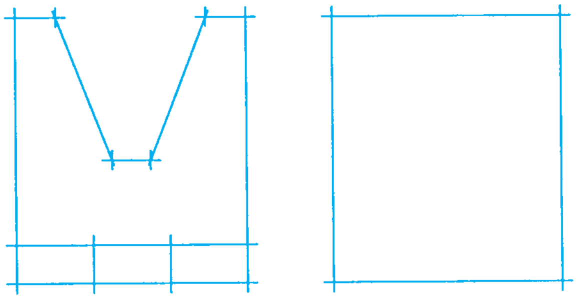
PROBLEM 8.64 Clevis

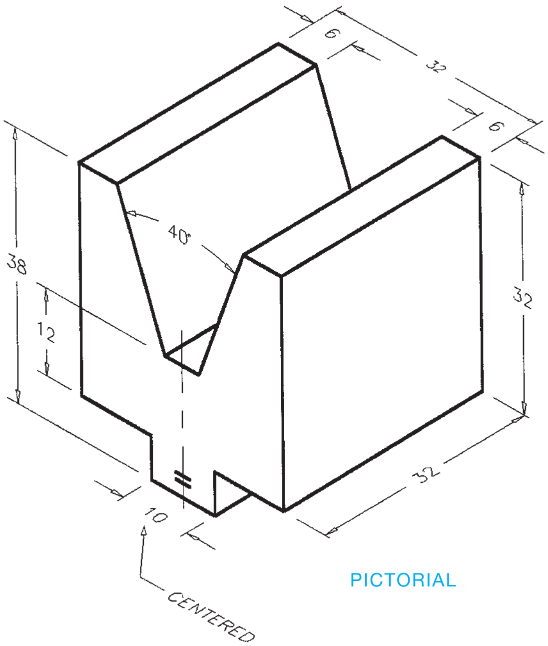


Part 5: Problems 8.65 and 8.66

Problems 8.65 and 8.66 provide you with pictorial views that contain dimensions. A suggested view layout is provided for your reference. Draw the required views. The pictorial views are provided to aid in visualization. You do not need to draw the pictorial view. Use the given dimensions to create your formal drawing. Set up your drawings with a properly sized sheet, border, and sheet block. Properly complete the information in the title block. Do not draw the dimensions.

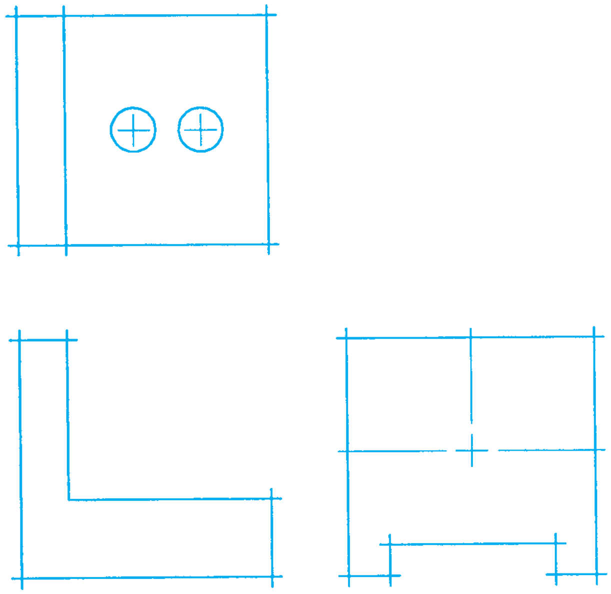
PROBLEM 8.65 V-block (metric)

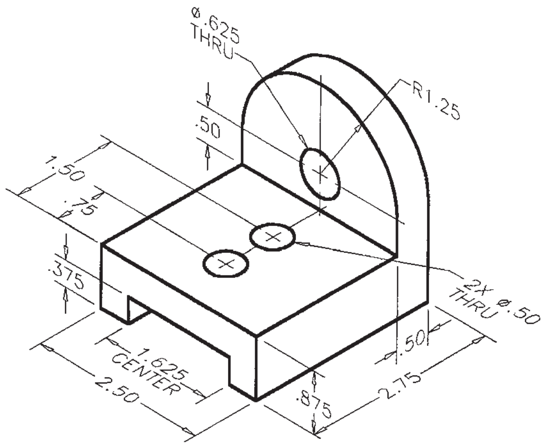




PICTORIAL

PROBLEM 8.66 Guide base (in.)





PICTORIAL

Part 6: Problems 8.67 Through 8.99

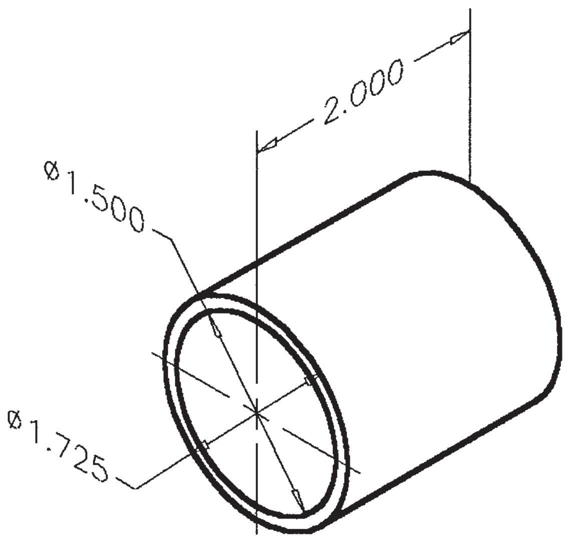
Problems 8.67 through 8.99 provide pictorial views or multiview layouts that contain dimensions. Use the given information to select and draw the necessary multiviews. In some cases, the suggested number of views is given. Do not draw the pictorial view. Set up your drawings with a properly sized sheet, border, and sheet block. Properly complete the information in the title block. Do not draw the dimensions.

PROBLEM 8.67 **One-view cylindrical object (in.)**

Part Name: Sleeve bearing

Material: Phosphor bronze

Problem based on original art courtesy of Production Plastics.

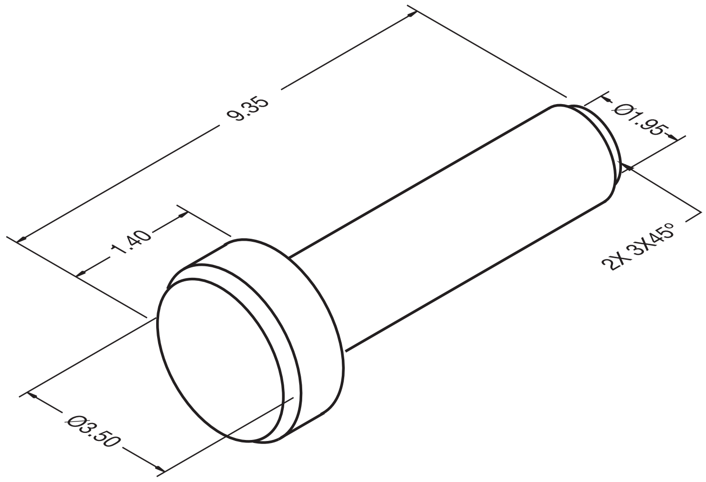


PROBLEM 8.68 **One-view cylindrical object (in.)**

Part Name: Pin

Material: SAE1035

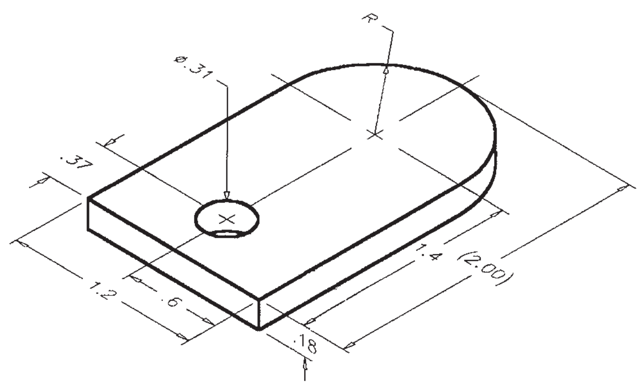
Problem based on original art courtesy of Production Plastics.



PROBLEM 8.69 **One-view arc and hole (in.)**

Part Name: Door Lock

Material: Mild steel



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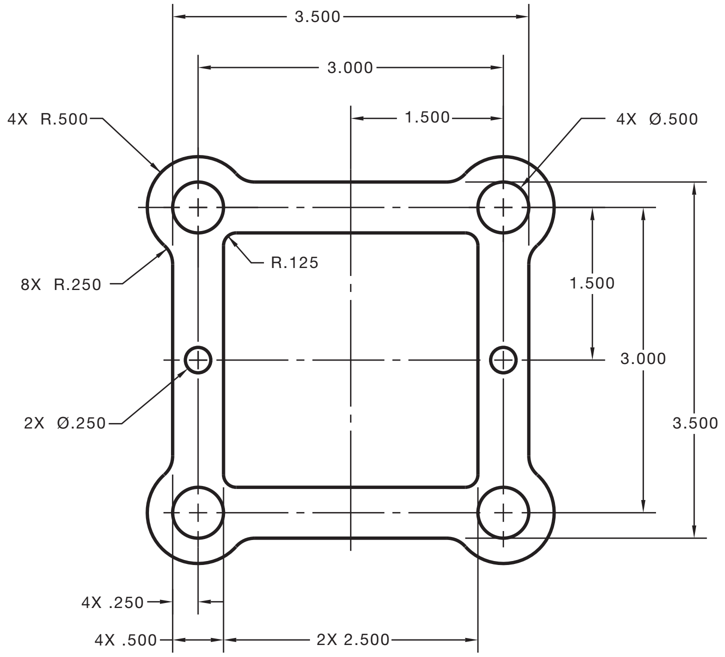
PROBLEM 8.70 One-view arcs, circles, and centerlines (in.)

Part Name: Gasket

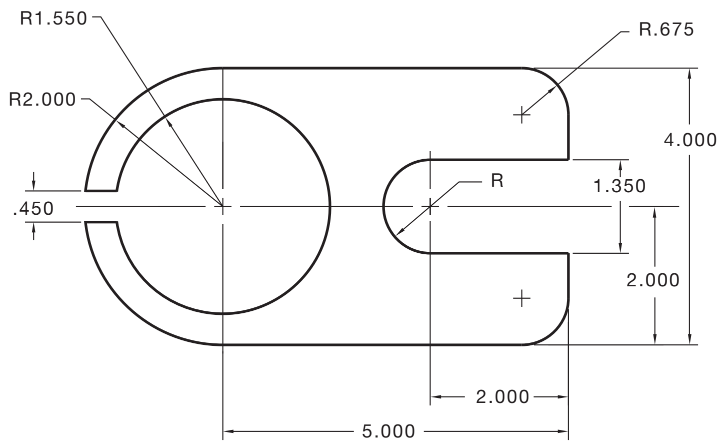
Material: .050 in. thick brass



PROBLEM 8.71 One-view arcs and centerlines (in.)

Part Name: Clip

Material: .025 in. thick SAE 3140

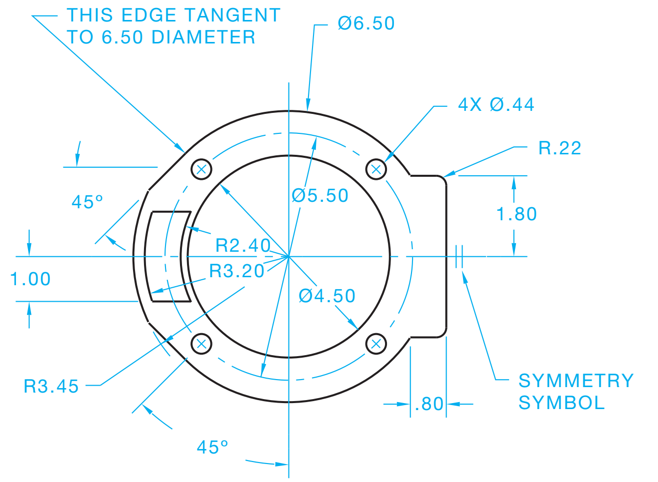


PROBLEM 8.72 One-view circle and arc object lines and centerlines (in.)

Part Name: Gasket

Material: .062 in. thick cork

Gasket for hydraulic pump.

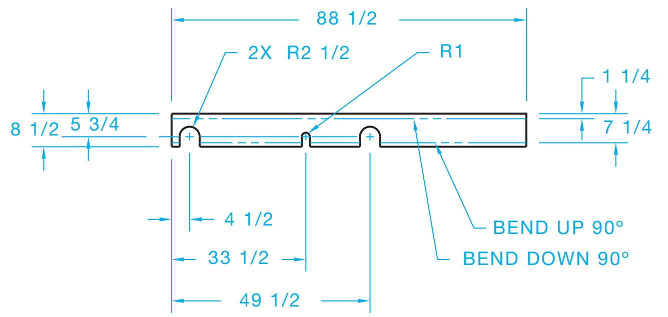


PROBLEM 8.73 Arc object lines, centerlines, phantom lines, and leader lines (in.)

Part Name: Bogie Lock

Material: .25 in. thick mild steel

Specific Instructions: Connect the leader lines and place the notes on the drawing.

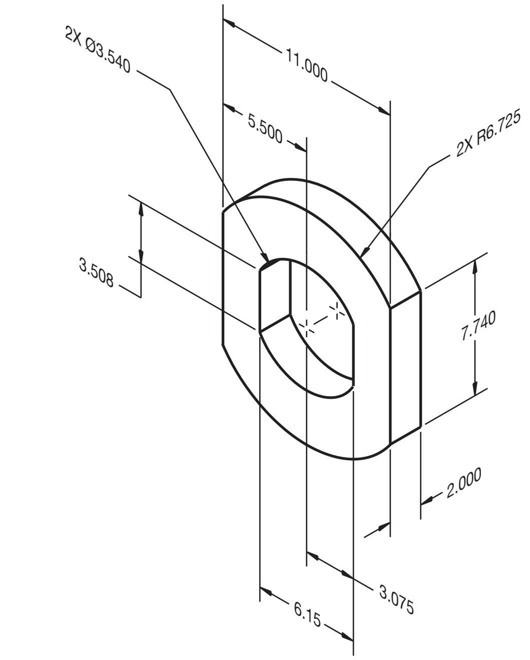


NOTE: Make bend line centerline type.

PROBLEM 8.74 Two views nontangent arcs (in.)

Part Name: Washer

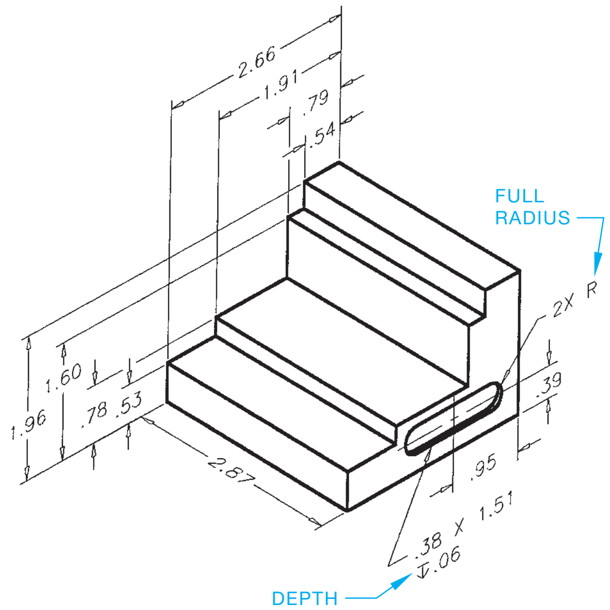
Material: SAE 1060



PROBLEM 8.75 Planes and slot (in.)

Part Name: Step Block

Material: Mild steel

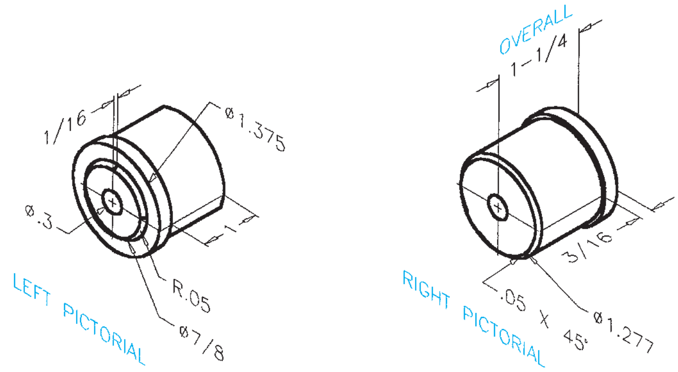


PROBLEM 8.76 Cylinders and circles (in.)

Part Name: Roll End Bearing

Material: Phosphor bronze

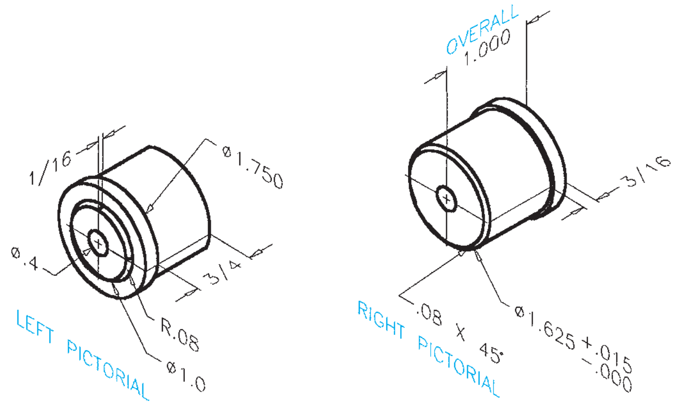
Problem based on original art courtesy of Production Plastics.



PROBLEM 8.77 Cylinders and circles (in.)

Part Name: Roll End Bearing

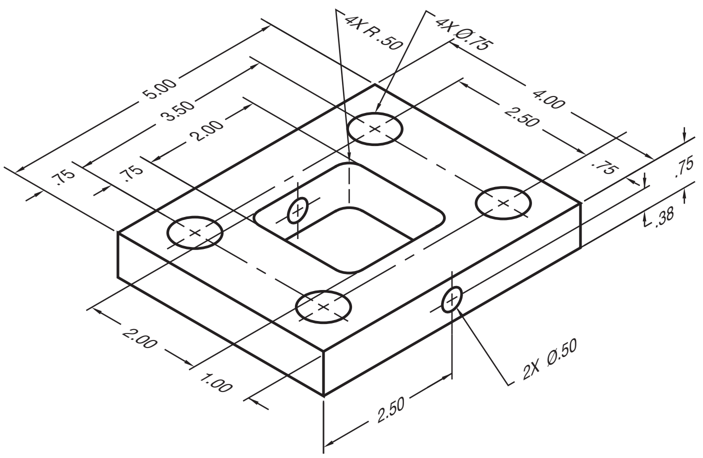
Material: Phosphor bronze



PROBLEM 8.78 Two views with holes (in.)

Part Name: Pivot Bracket

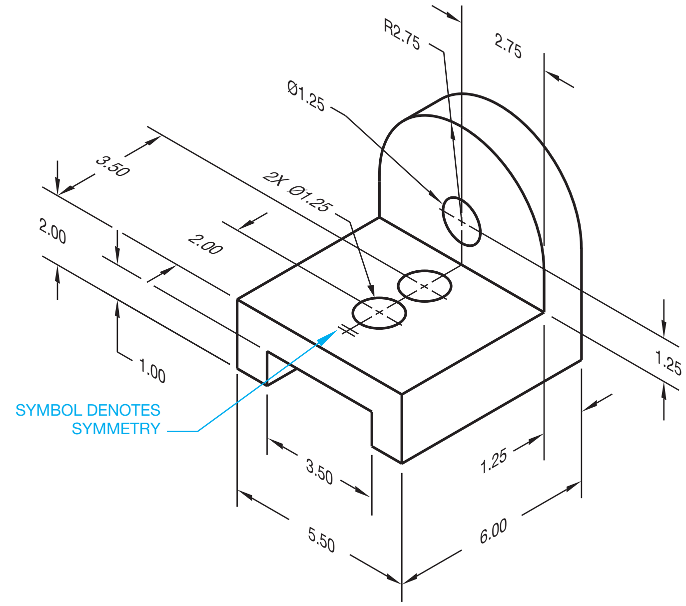
Material: SAE 3135



PROBLEM 8.79 Three views with holes and slot (in.)

Part Name: Sliding Bracket

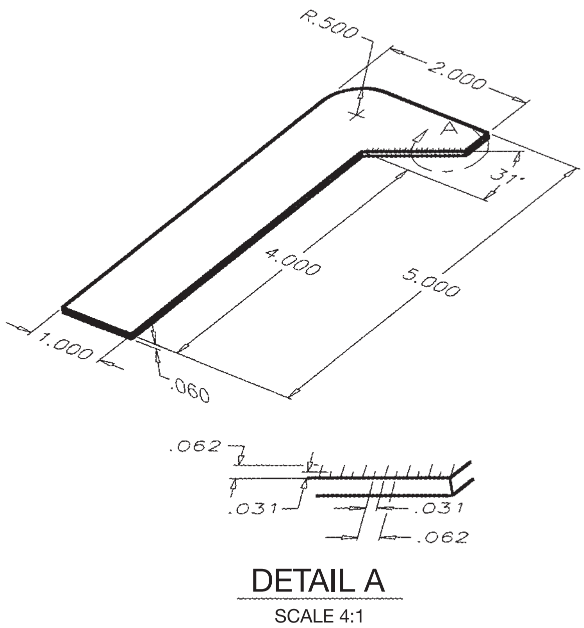
Material: Phosphor bronze



PROBLEM 8.81 View enlargement (in.)

Part Name: Drill Gauge

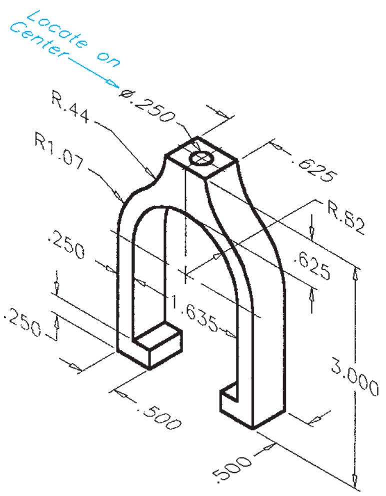
Material: 16-GA mild steel



PROBLEM 8.80 Circle arcs and planes (in.)

Part Name: V-block Clamp

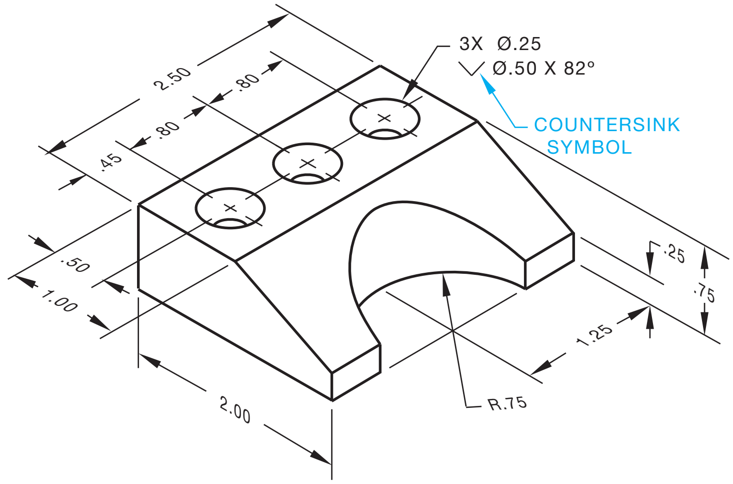
Material: SAE 1080



PROBLEM 8.82 Two views with angled surface, countersinks (in.)

Part Name: Angle Bracket

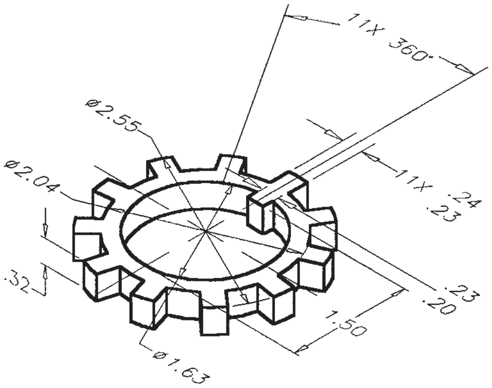
Material: SAE 1145



PROBLEM 8.83 Multiple features (in.)

Part Name: Lock Ring

Material: SAE 1020



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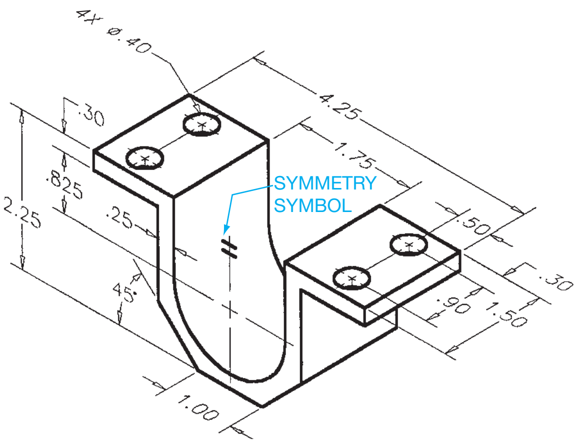
PROBLEM 8.84 Angles and holes (in.)

Part Name: Bracket

Material: SAE 1020



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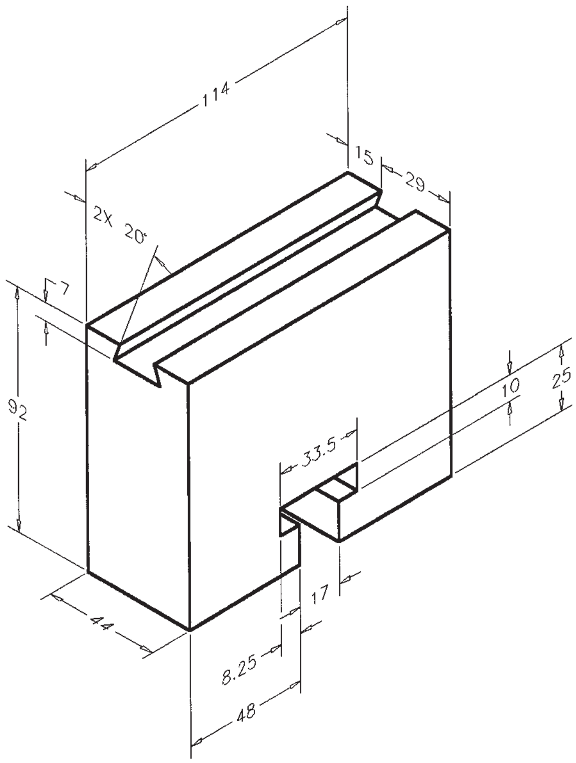
PROBLEM 8.85 Multiviews (metric)

Part Name: Guide Rail

Material: SAE 4310



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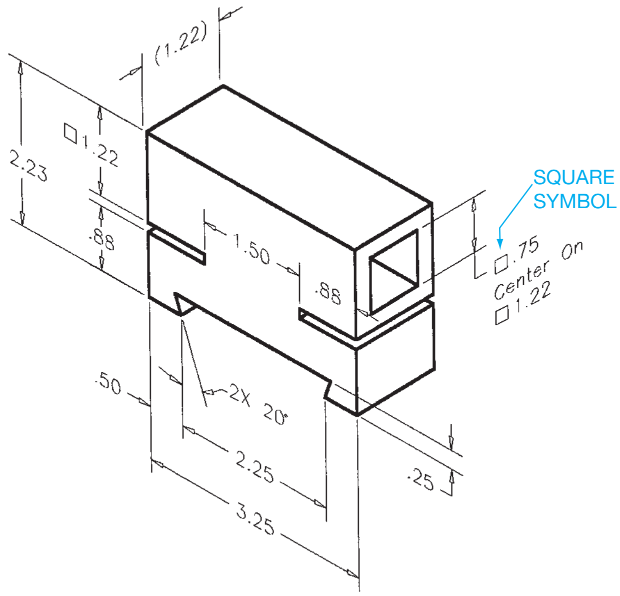
PROBLEM 8.86 Multiviews (in.)

Part Name: Support Bracket

Material: Plastic



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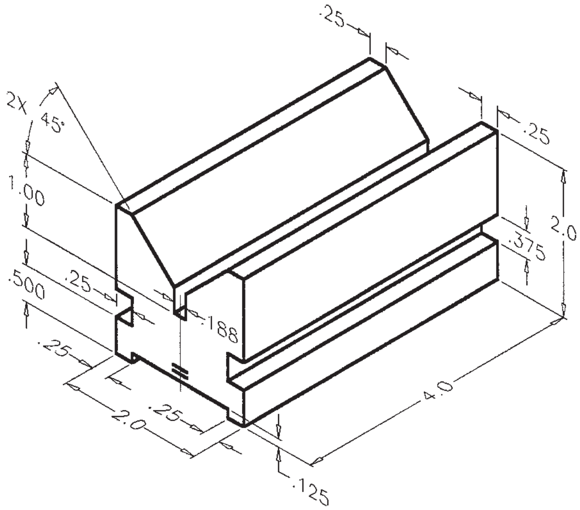
PROBLEM 8.87 **Multiviews (in.)**

Part Name: V-block

Material: A-steel

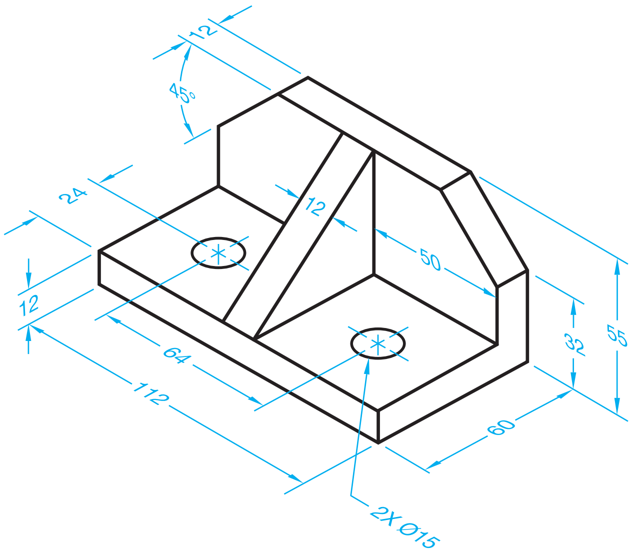


PROBLEM 8.88 **Multiviews, angles, and holes (metric)**

Part Name: Angle Bracket

Material: Mild steel

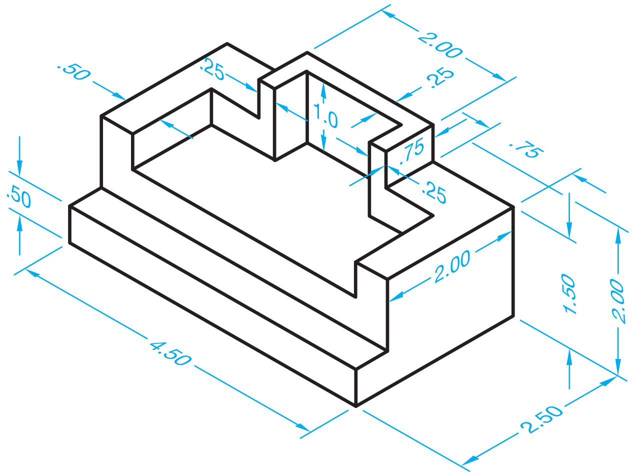
Specific Instructions: Center 2X Ø15 holes and provide location dimension.



PROBLEM 8.89 **Multiviews (in.)**

Part Name: Support

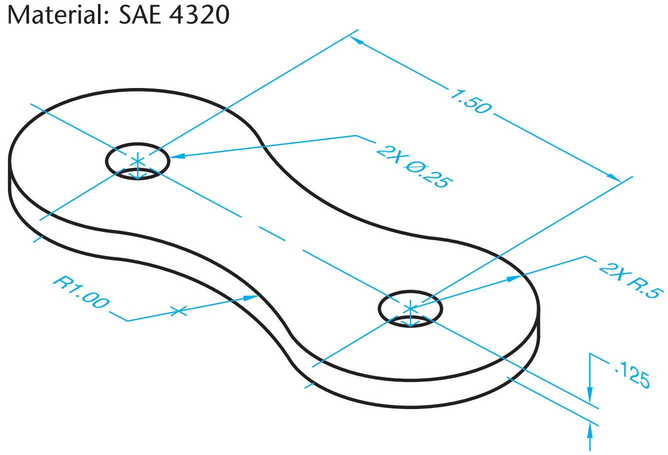
Material: Mild steel



PROBLEM 8.90 **Multiviews, circles, and arcs (in.)**

Part Name: Chain Link

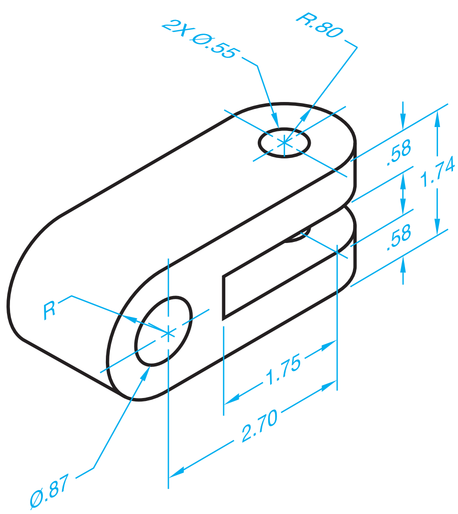
Material: SAE 4320



PROBLEM 8.91 **Multiviews, circles, and arcs (in.)**

Part Name: Pivot Bracket

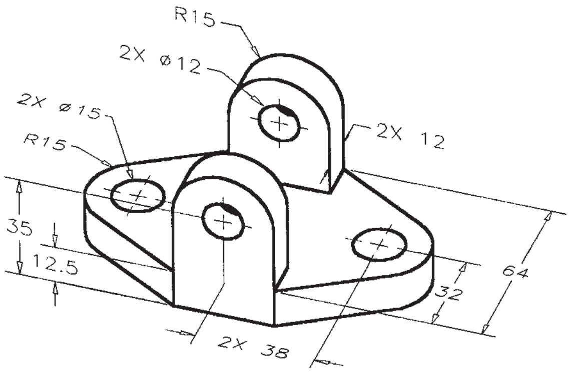
Material: Cold-rolled steel



PROBLEM 8.92 Multiview arcs and circles (metric)

Part Name: Hinge Bracket

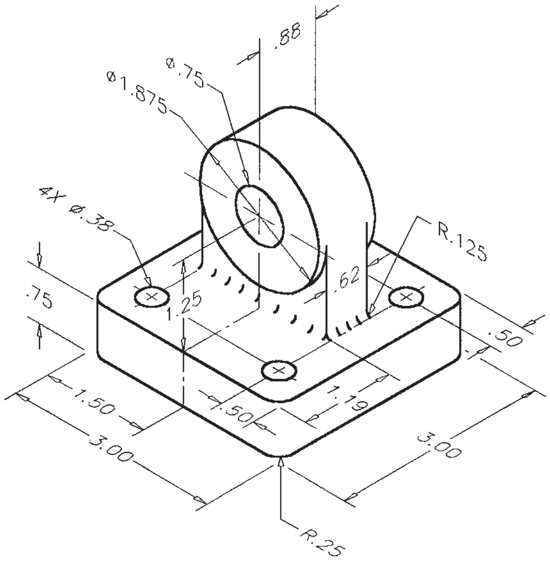
Material: Cast aluminum



PROBLEM 8.93 Multiview circles and arcs (in.)

Part Name: Bearing Support

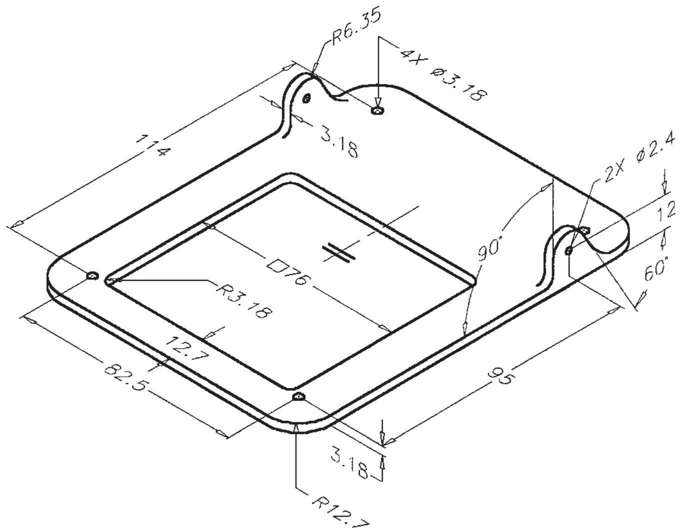
Material: SAE 1040



PROBLEM 8.94 Multiviews (metric)

Part Name: Gate Latch Base

Material: Aluminum

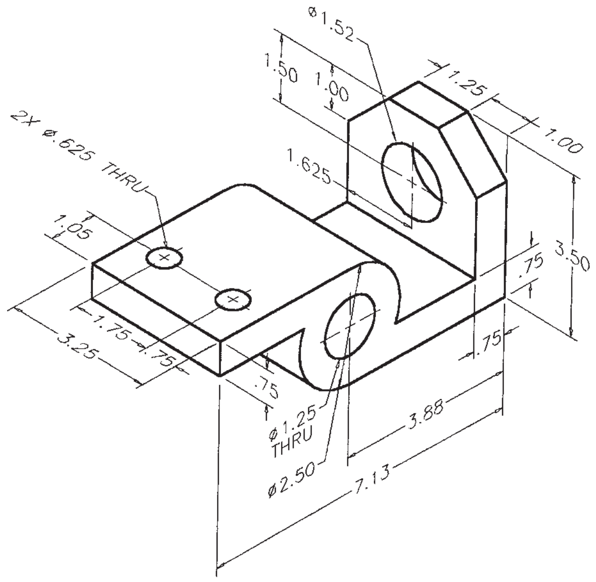


PROBLEM 8.95 Multiviews (in.)

Part Name: Mounting Bracket

Material: SAE 1020

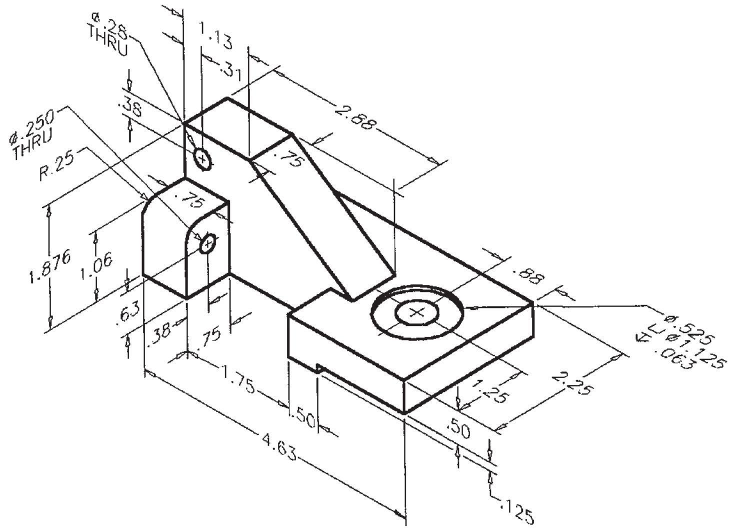
All Fillets: R.13



PROBLEM 8.96 **Multiviews (in.)**

Part Name: Support Base

Material: SAE 1040

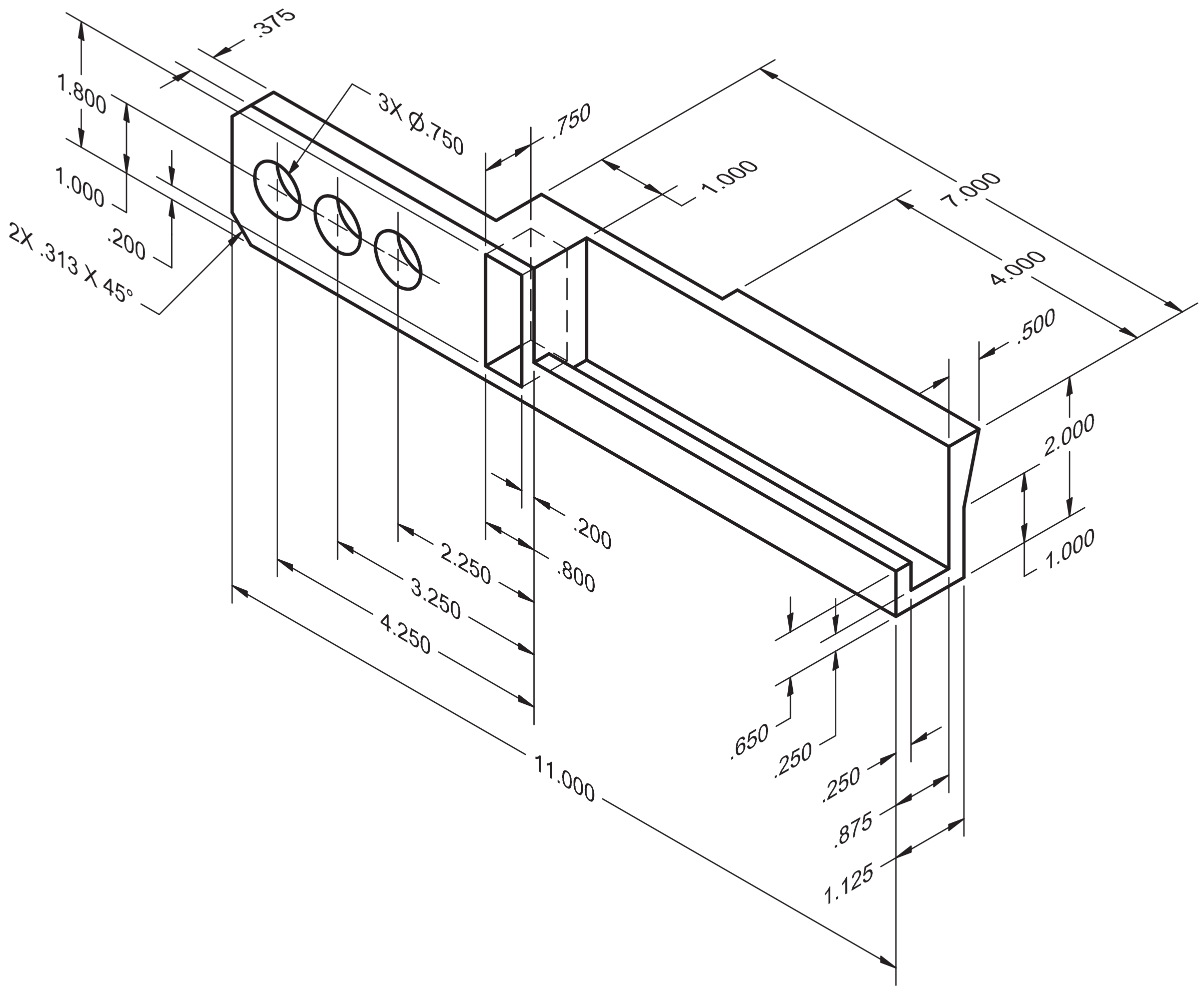


PROBLEM 8.97 **Multiviews (in.) removed view**

Part Name: Draw Bar

Material: SAE 4320

Draw a front view, top view, and standard removed view using a labeled viewing-plane line and correlated removed side view.

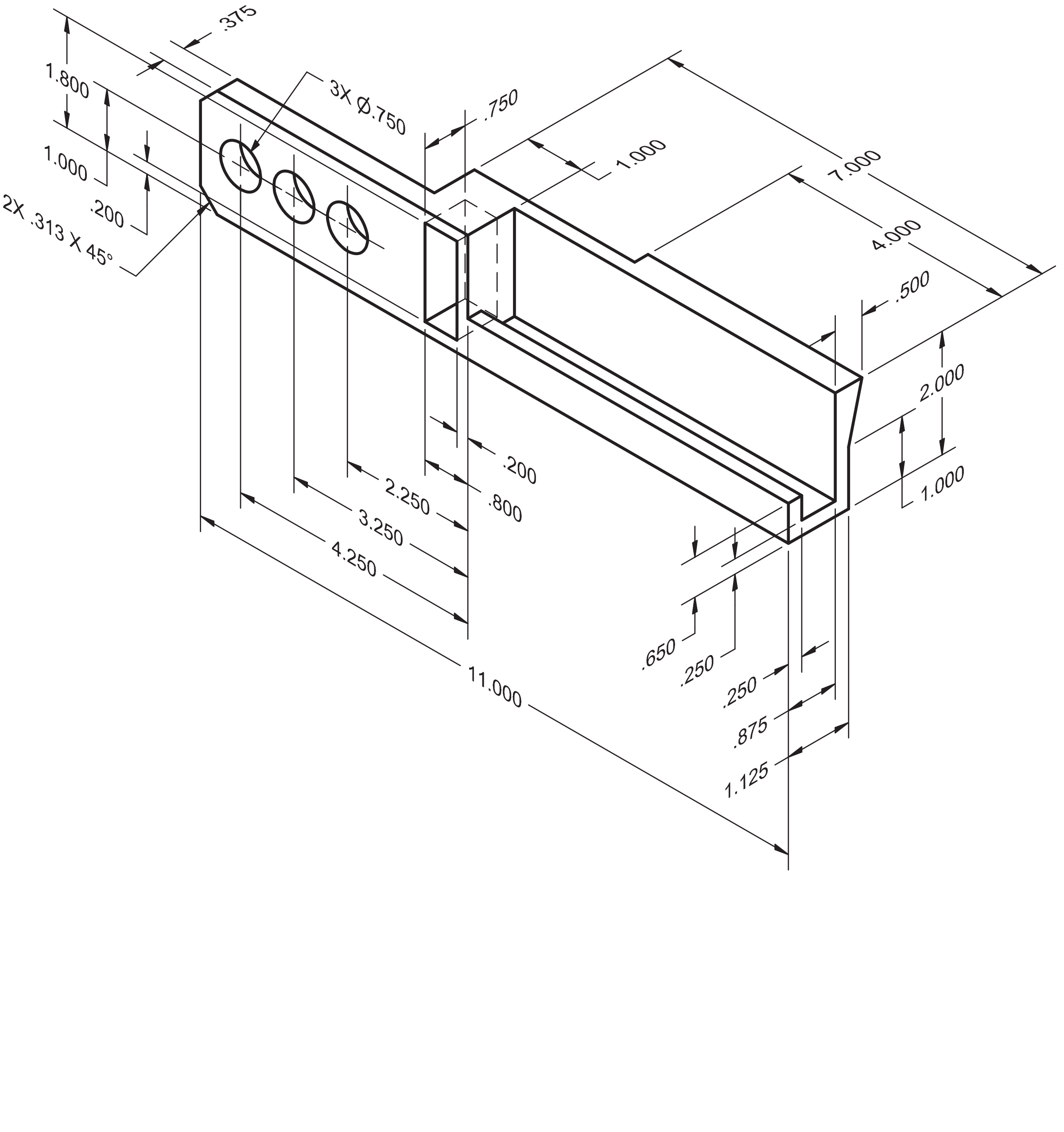


PROBLEM 8.98 **Multiviews (in.) removed view arrow method**

Part Name: Draw Bar

Material: SAE 4320

Using the same part shown in Problem 8.97, draw a front view, top view, and removed view using the arrow method. Label the viewing arrow and correlated removed side view.

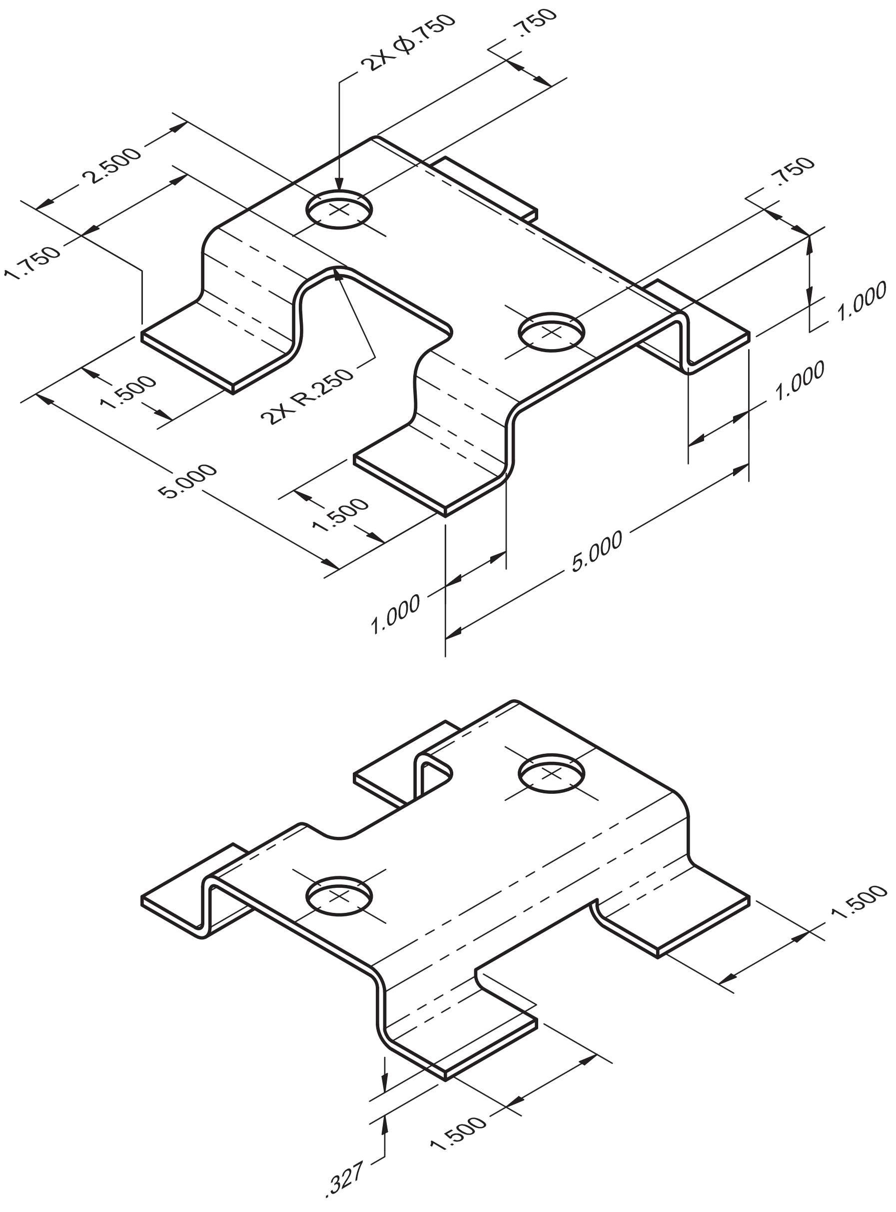


PROBLEM 8.99 **Multiviews (in.) sheet metal part**

Part Name: Bracket

Material: 11 gage (.1196 in.) SAE 1040 steel.

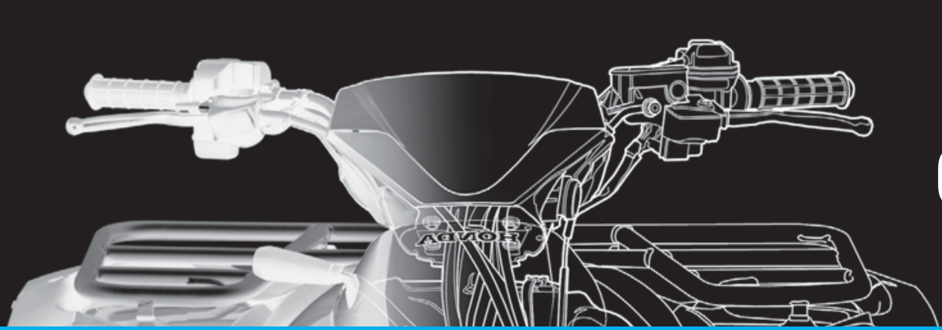
The bend radius is equal to the thickness of the material.



Math Problems

Part 7: Problems 8.100 Through 8.110

To access the Chapter 8 problems, go to the Student CD, select **Chapter Tests and Problems** and **Chapter 8**, and then open the math problem of your choice or as assigned by your instructor. Solve the problems using the instructions provided on the CD, unless otherwise specified by your instructor.



CHAPTER 9

Auxiliary Views

LEARNING OBJECTIVES

After completing this chapter, you will:

- Describe the purpose of an auxiliary view.
- Explain how an auxiliary view is projected.
- Discuss and draw viewing-plane lines related to auxiliary views.
- Draw primary and secondary auxiliary views along with the related multiviews from given engineering problems.

THE ENGINEERING DESIGN APPLICATION

You have been asked to create a multiview detail drawing for a guide bracket, and the engineer has provided a sketch of the part (see Figure 9.1). As you study the sketch, you discover that one of the surfaces on the bracket is not parallel to any of the six principal viewing planes. You determine that your multiview drawing needs an auxiliary view in order to show the angled face in its true size and shape as a true geometric view. Through sketching your layout ideas, you conclude that a complete auxiliary view would not add clarity to the drawing and decide instead on a partial auxiliary view. Figure 9.2 shows the final layout.

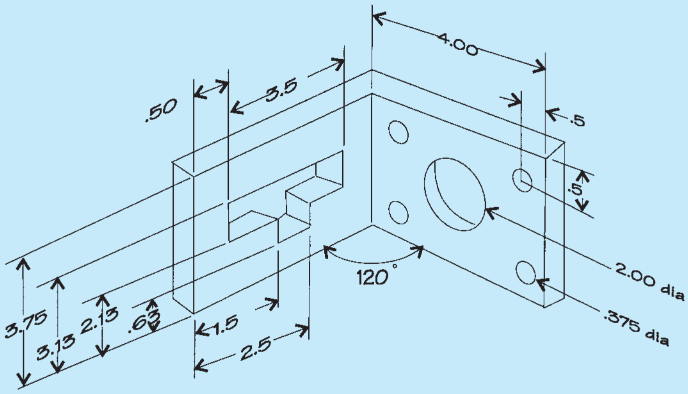


FIGURE 9.1 Engineer's rough sketch. *© Cengage Learning 2012*

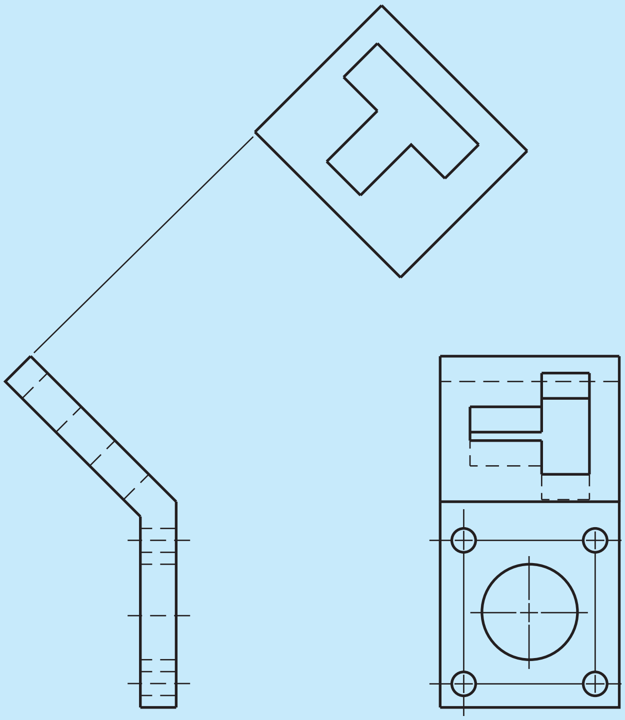


FIGURE 9.2 Final layout with partial auxiliary view (dimensions not included). *© Cengage Learning 2012*

STANDARDS

ASME The standard for auxiliary view presentation is found in ASME Y14.3, *Multi and Sectional View Drawings*.

AUXILIARY VIEWS

Auxiliary views are used to show the true size and shape of a surface that is not parallel to any of the six principal views. Reasons for using auxiliary views include the following:

- To find the true length of a sloping line.
- To find the true size and shape of an inclined surface.
- To find the point view of an inclined line.
- To look at the object in a different plane that is not one of the principal planes so the object can be viewed differently or to start successive auxiliary views.

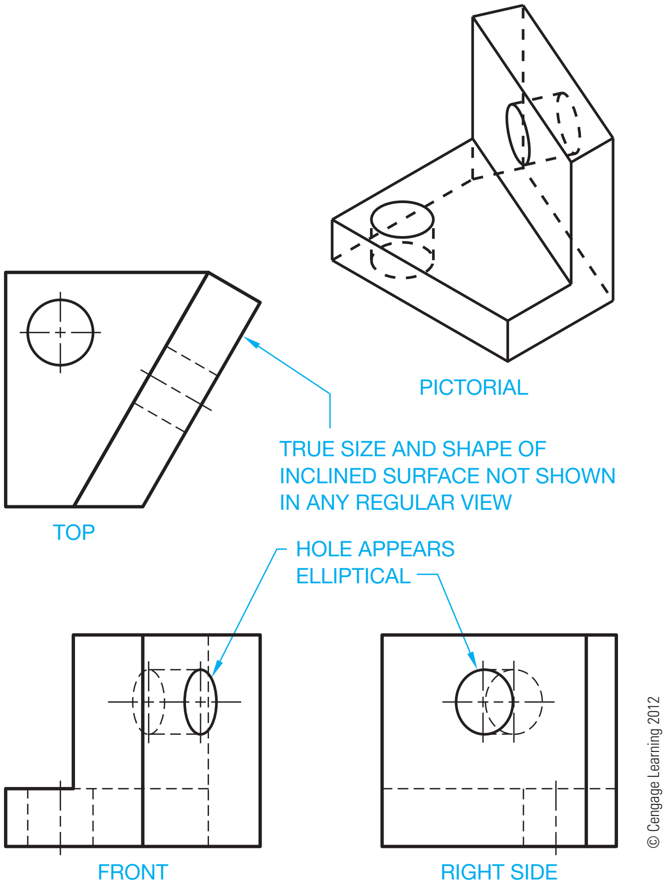


FIGURE 9.3 Foreshortened surface auxiliary view.

When a surface feature is not perpendicular to the line of sight, the feature is said to be *foreshortened* or to be shorter than true length. These foreshortened views do not give a clear or accurate representation of the feature. It is not proper to place dimensions on foreshortened views of objects. Figure 9.3 shows three views of an object with an inclined foreshortened surface.

An auxiliary view allows you to look directly at the inclined surface in Figure 9.3 so you can view the surface and locate the hole in its true size and shape. An auxiliary view is projected from the inclined surface in the view where the inclined surface appears as a line or edge. The projection is at a 90° angle from the view where the inclined surface appears as a line (see Figure 9.4). The height dimension, *H*, is taken from the view that shows the height in its true length.

Notice in Figure 9.4 that the auxiliary view shows only the true size and shape of the inclined surface. This is known as a **partial auxiliary view**. The **full auxiliary view** in Figure 9.5 shows the true size and shape of the inclined surface and all the other features of the object projected onto the auxiliary plane. Normally, a partial auxiliary view is used because the partial auxiliary view shows only what you need to provide the true geometry of the inclined surface. The other features do not usually add clarity to the view.

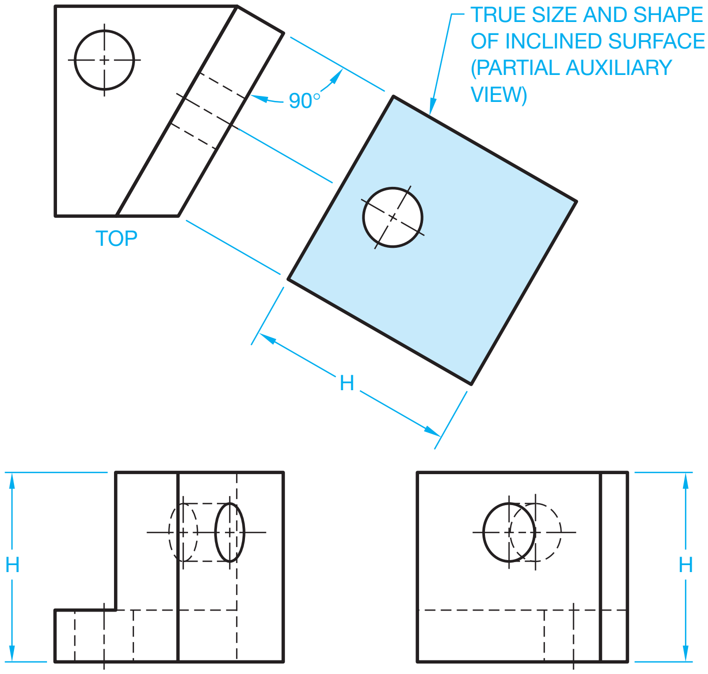


FIGURE 9.4 Partial auxiliary view. © *Cengage Learning 2012*

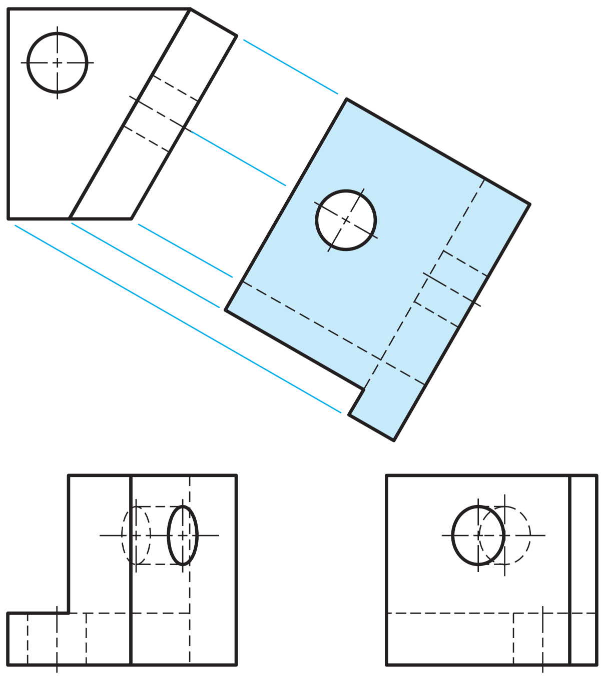


FIGURE 9.5 Complete auxiliary view. © *Cengage Learning 2012*

The glass box method of visualization was introduced in Chapter 8. Look at the glass box principal shown in Figure 9.6 as it applies to auxiliary views. Notice that there are planes on the glass box that establish the front, top, and right-side views. There is also a plane parallel to the inclined surface used to establish the auxiliary view. Figure 9.7 shows the glass box unfolded. Notice that the fold line between the front view and the auxiliary view is parallel to the edge view of the slanted surface. The auxiliary view is projected 90° from the edge view of the inclined surface. This projection establishes true length. The true width of the inclined surface can be transferred from the fold lines of the top or side views as shown in Figure 9.8.

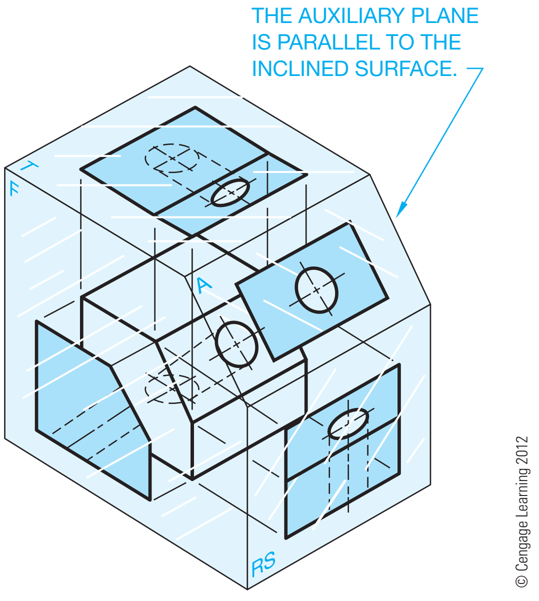


FIGURE 9.6 The object in a glass box.

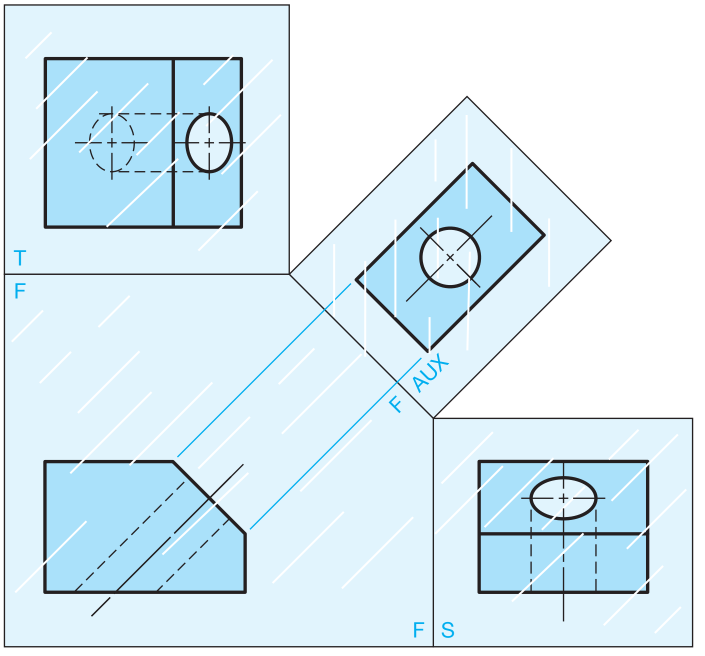
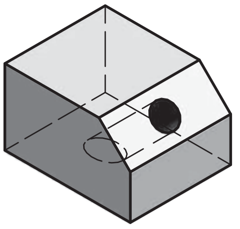


FIGURE 9.7 The glass box unfolded. *© Cengage Learning 2012*



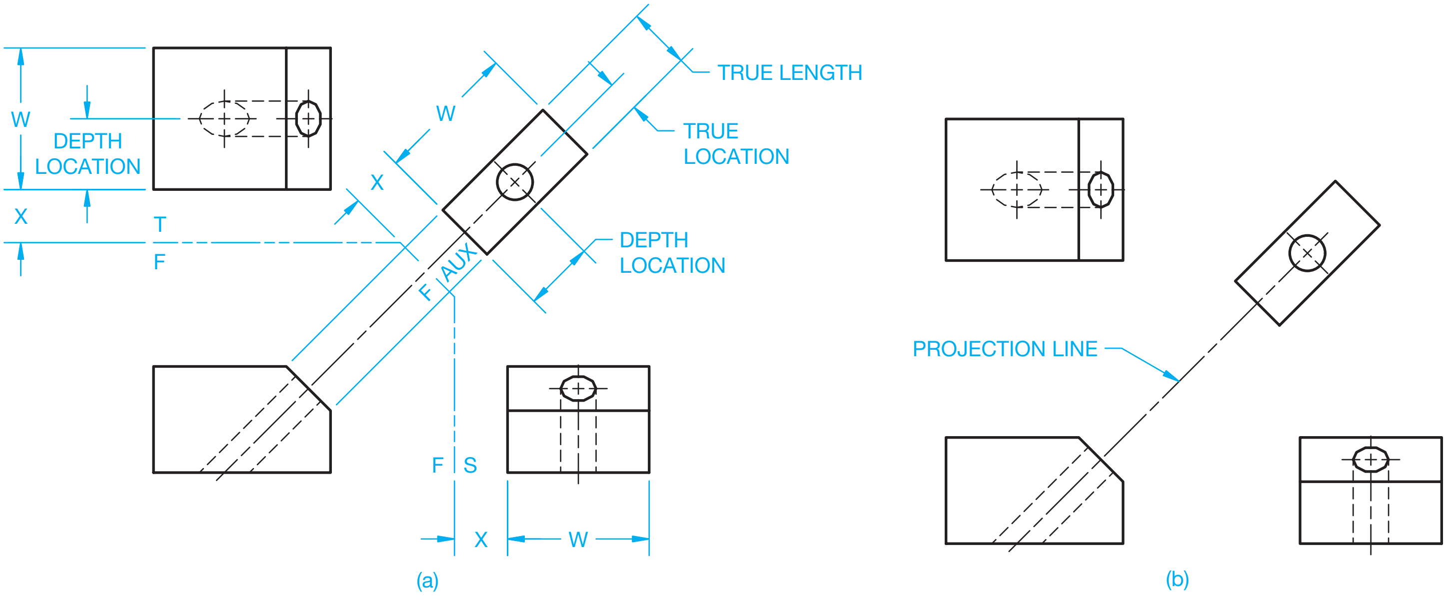


FIGURE 9.8 (a) Establishing auxiliary view with fold lines. (b) The final multiview drawing with auxiliary view. *© Cengage Learning 2012*

Projection lines are drawn as construction lines and should be on a special layer that can be turned off or frozen when finished. Hidden lines are generally not shown on auxiliary views unless the use of hidden lines helps clarify certain features.

The auxiliary view can be projected directly from the inclined surface as shown in Figure 9.8a. When the auxiliary view is completed, one projection line remains between the views to indicate alignment and view relationship. The projection line that you keep on the final drawing can be from a corner or it can be a centerline that extends between views. Figure 9.8b shows the completed multiview drawing with auxiliary view. The projection centerline or projection line is often used as an extension line for dimensioning purposes. If view alignment is clearly obvious, then the projection line can be omitted.

AUXILIARY VIEW VISUALIZATION

Multiview and auxiliary view visualization can be difficult. It is important for you to practice looking at three-dimensional (3-D) objects and try to visualize them in two-dimensional (2-D) views in your mind. Figure 9.9 shows examples of partial auxiliary views in use. Look at the multiview and auxiliary view drawings in Figure 9.12 and compare these 2-D views to the pictorial views provided.

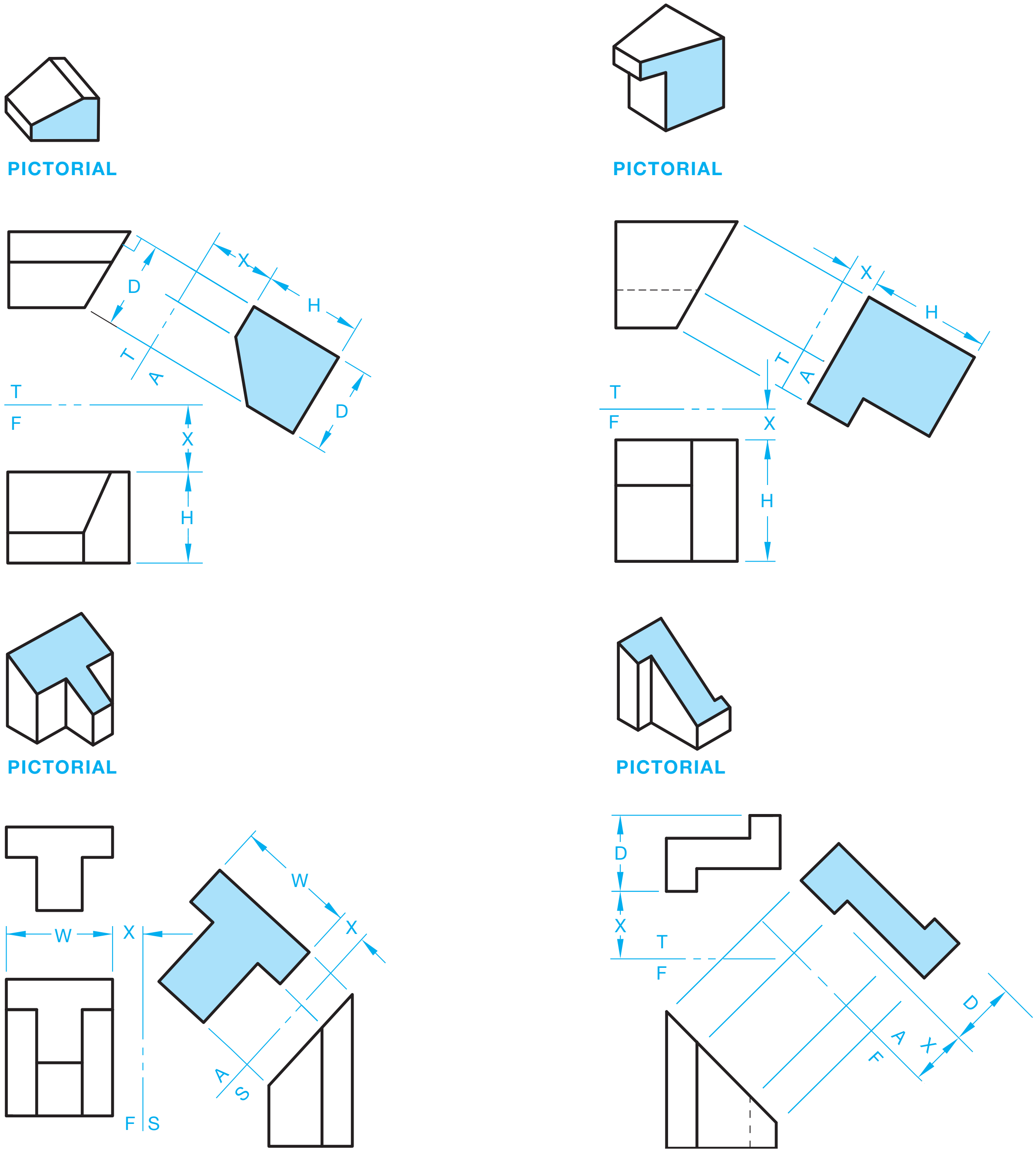


FIGURE 9.9 Partial auxiliary view examples. © *Cengage Learning 2012*

Using the Mechanics of View Projection to Visualize and Draw Auxiliary Views

It is important to visualize the relationship of the slanted surfaces, edge view, and auxiliary view. If you have trouble with visualization, it is possible to establish the auxiliary view through the mechanics of view projection by using the following steps:

STEP 1 Number each corner of the inclined view so the numbers coincide from one view to the other as shown in Figure 9.10. Carefully project one point at a time from view to view. Some points have two numbers, depending on the view. When you look at a line from the end, the line looks like a point. When you see a point with two numbers, the two numbers represent each end of the line in an end view. The first number is the end point closest to you and the second number is the end point farthest away from you. Notice how the fold lines are placed between views and labeled in Figure 9.11. The front view side of the fold line is labeled F, the side view side is labeled S, and the top view side is labeled T.

STEP 2 With the corresponding points numbered in each view, draw an auxiliary fold line parallel to the edge view of the slanted surface. The auxiliary fold line can be any convenient distance from the edge view. Your line of sight for the auxiliary view is perpendicular to the edge view of the foreshortened surface. Draw projection lines perpendicular to the fold line to begin creating the auxiliary view. Project the points on the edge view perpendicular (90°) across the auxiliary fold line. Notice how the fold line is placed between the side and auxiliary view and labeled. The side view side of the fold line is labeled S, the auxiliary view side is labeled AUX (see Figure 9.11). The vertical fold line (reference plane) between the front and right side views is used to establish the width dimensions (see Figure 9.11).

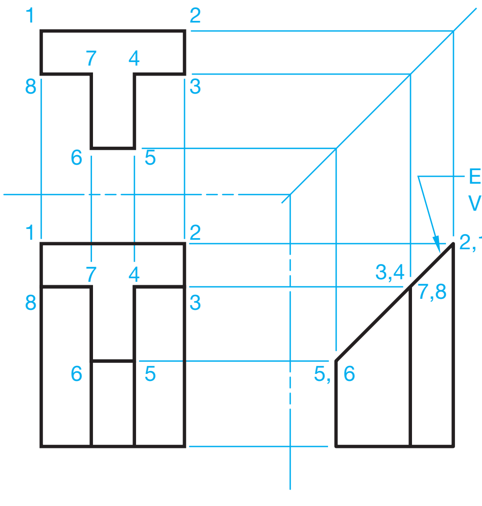


FIGURE 9.10 Step 1: Multiview layout. © *Cengage Learning 2012*

STEP 3 Establish the distance to each point from the adjacent view and transfer the distance to the auxiliary view as shown in Figure 9.12a. Sometimes it is helpful to sketch a small pictorial to assist in visualization as shown in Figure 9.12b. You get the true width measurements from either the front or top views. The front view is used, in this example, to get the width measurements in Figure 9.12a. Measure the distance X from the fold line to the front view and the width W in the front view as shown in Figure 9.12a. Connect the points to create the true size and shape of the foreshortened surface, which is the desired auxiliary view you are trying to establish (see Figure 9.12a).

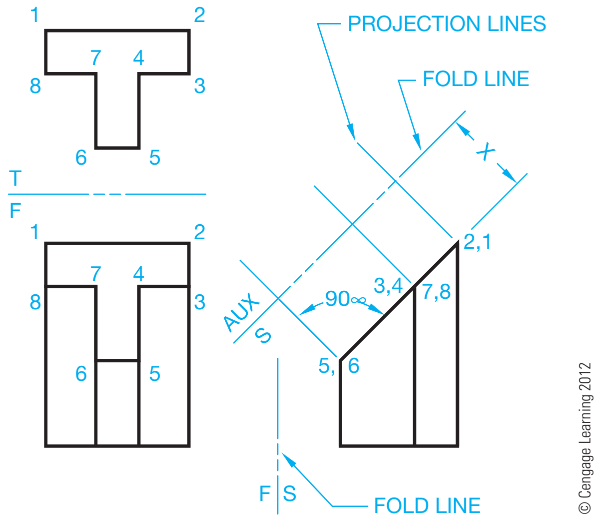


FIGURE 9.11 Step 2: Establish the auxiliary (AUX) fold line.

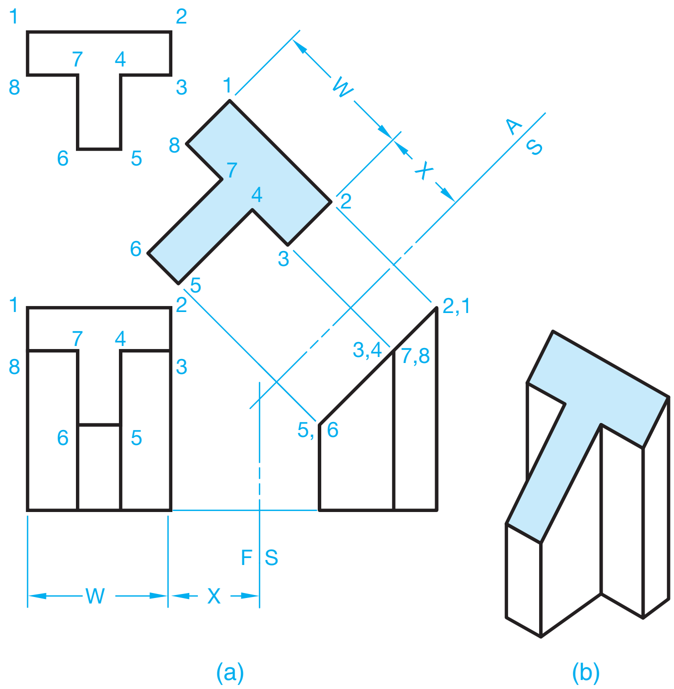


FIGURE 9.12 (a) Step 3: Layout auxiliary view. (b) Pictorial to help visualize object. © *Cengage Learning 2012*

DRAWING CURVES IN AUXILIARY VIEWS

Curves are drawn in auxiliary views in the same manner as those shapes described previously, except the process can be more detailed. When corners exist, they are used to lay out the extent of the auxiliary surface. An auxiliary surface with irregular curved contours requires the curve be divided into elements so the element points can be transferred from one view to the next, as shown in Figure 9.13.

The contour of elliptical shapes can be plotted as shown in Figure 9.14. Use a command such as ELLIPSE to set the major and minor diameters followed by picking the center point at the desired ellipse location.

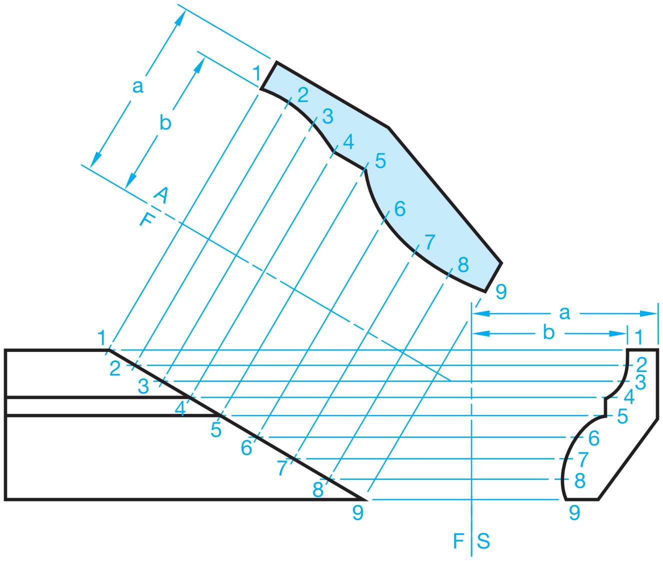


FIGURE 9.13 Plotting curves in auxiliary view. © *Cengage Learning 2012*

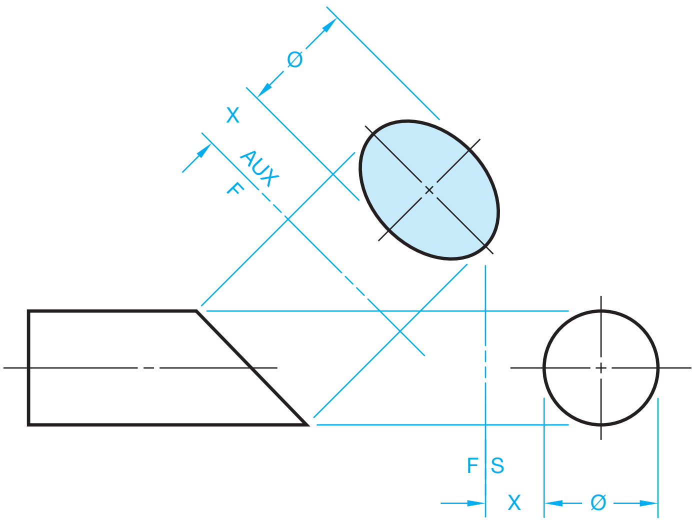


FIGURE 9.14 Elliptical auxiliary view. © *Cengage Learning 2012*

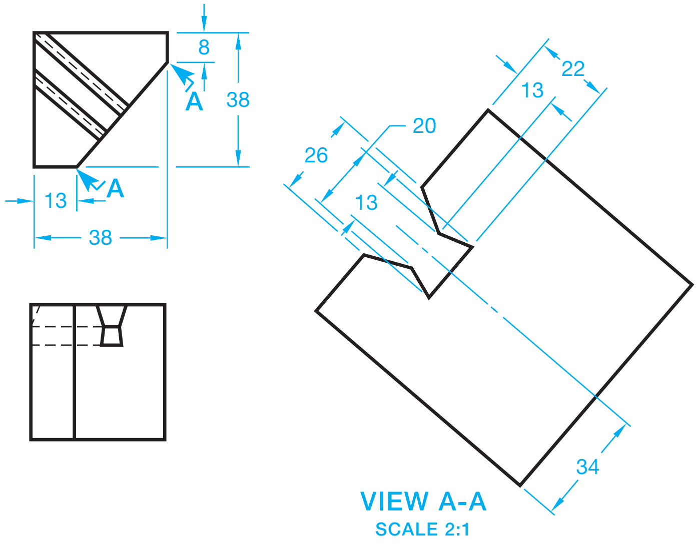


FIGURE 9.15 Auxiliary view enlargement. © *Cengage Learning 2012*

VIEW ENLARGEMENTS

In some situations, you may need to enlarge an auxiliary view so small detail can be shown more clearly. Figure 9.18 shows an object with a foreshortened surface. The two principal views are clearly dimensioned at a 1:1 scale. The 1:1 scale is too small to clarify the shape and size of the slot through the part. A viewing-plane line is placed to show the relationship of the principal view to the auxiliary view. The auxiliary view can then be drawn in any convenient location at any desired scale. The auxiliary view in Figure 9.15 is drawn at a 2:1 scale.

DRAWING A REMOVED AUXILIARY VIEW

When it is not possible to align the auxiliary view directly from the inclined surface, then a viewing-plane line can be used and the view placed in a convenient location on the drawing as shown in Figure 9.16. The viewing-plane line arrowheads maintain the same 3:1 length-to-width ratio as dimension-line arrowheads. Viewing-plane line arrowheads are generally twice the size of dimension-line arrowheads, so they show up better on the drawing. If the dimension-line arrowheads are .125 in. (3 mm) long on your drawing, then make the viewing-plane line arrowheads .25 in. (6 mm) long. This depends on the size of the drawing and your school or company standards. The viewing-plane line is labeled with letters so the view can be clearly identified. This is especially necessary when several viewing-plane lines are used to label different auxiliary views. Place views in the same relationship as the viewing-plane lines indicate and as if the auxiliary view were projected from the slanted surface. Do not rotate the auxiliary. Where multiple views are used, orient views from left to right and from top to bottom. The views are labeled to correlate with their viewing plane, such as VIEW A-A for the first view, VIEW B-B for the second view, and VIEW C-C for the third view. The title VIEW A-A uses a text height of .24 in. (6 mm).

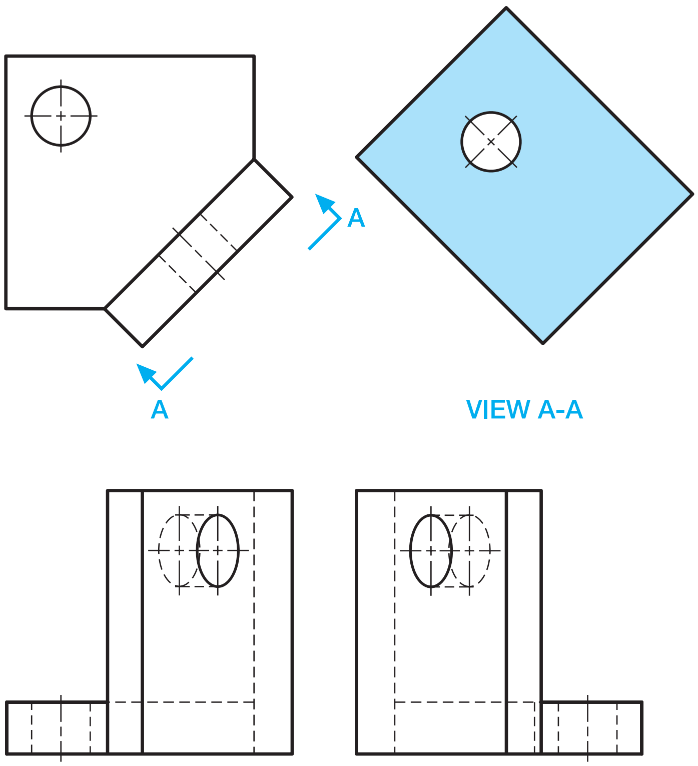


FIGURE 9.16 Establishing auxiliary view with viewing plane. *© Cengage Learning 2012*

LOCATING VIEWS ON DIFFERENT SHEETS

This chapter describes the various methods used for displaying viewing-plane lines and related views. The preferred method is to project the auxiliary view directly from a principal view. Alternately, you can place labeled viewing-plane lines where needed and locate the related auxiliary view in another place on the same sheet. When using this method, each auxiliary view has a title correlated to the viewing-plane lines as previously described.

When necessary, locate auxiliary views on a sheet other than where the viewing-plane lines appear. The method for doing this is called cross-reference zoning, and it is used to indicate the location of a view back to the viewing location on a previous page. The auxiliary view is located on a different page and is labeled with the sheet number and zone of the cross-reference viewing plane. ASME Y14.3 does not recommend a specific zone and page identification system. The viewing plane and auxiliary views should have a note correlating each between sheets, such as LOCATED ON 2 ZONE B4 next to the viewing plane on the sheet where the viewing plane is located, and SEE SHEET 1 ZONE A5 next to the view on the sheet where the view is located. All sheets of a multiple-sheet drawing should be the same size. Each sheet has the same drawing number or part number. The sheets also have page numbers. For example, if there are three sheets, the first sheet is 1/3, the second sheet is 2/3, and the third sheet is 3/3. The format 1 OF 3, 2 OF 3, and 3 OF 3 can also be used. When a drawing has multiple sheets, the first sheet has the complete title block and other sheet blocks, including the angle of projection block and dimensioning and tolerance block. Additional sheets can have same set of blocks, or they can have a continuation sheet title block. The continuation sheet title block uses a minimum of the drawing number, scale, sheet size, CAGE code, and sheet number. Refer back to Chapter 8, Figure 8.36b, where you can see a continuous sheet title block. Any use of this practice should be confirmed with your school or company standards.

DRAWING A ROTATED AUXILIARY VIEW

It is preferred to align an auxiliary view with its principal view when possible. However, there is an option to rotate an auxiliary view when the normal auxiliary view placement takes up too much space on the sheet. When this is done, a viewing-plane line is used to indicate from where the view is taken, and the auxiliary view is placed in any desired location on the drawing. The auxiliary view is rotated as needed and the angle and direction of rotation is specified under the view title as shown in Figure 9.10. Notice in Figure 9.17 that the specification ROTATED 45° CW is placed under the view title. This means that the auxiliary view is rotated clockwise (CW) from its normal projection plane. If the view were rotated counterclockwise, the abbreviation CCW would have been placed after the rotation specification.

Using the Reference Arrow and Rotation Arrow Method

An optional reference arrow method can be used to show a removed auxiliary view. This method was introduced into ASME Y14.3 by the International Organization for Standardization (ISO). When this method is used, a viewing arrow with a view identification letter points to the location from where the view is taken. The auxiliary view is then placed in any desired location on the sheet and in the same orientation as the reference arrow. The view identification letter is placed above the auxiliary view as shown in Figure 9.18a. An optional rotation arrow method can be used to show a rotated auxiliary view with the

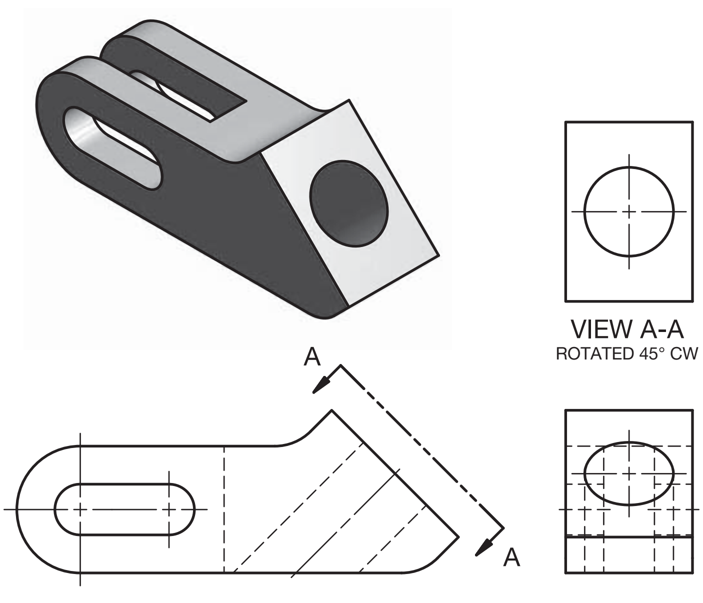


FIGURE 9.17 Establishing a rotated auxiliary view with a viewing-plane line. *© Cengage Learning 2012*

reference arrow method. When this method is used, a viewing arrow with a view identification letter points to the location from where the view is taken. The auxiliary view is then placed in any desired location on the drawing. The view identification letter, rotation arrow, and degrees of rotation are placed above the auxiliary view as shown in Figure 9.18b. The rotation arrow is also detailed in Figure 9.18b. If the rotation arrow points counterclockwise, the rotation is counterclockwise. The rotation is clockwise if the rotation arrow points clockwise.

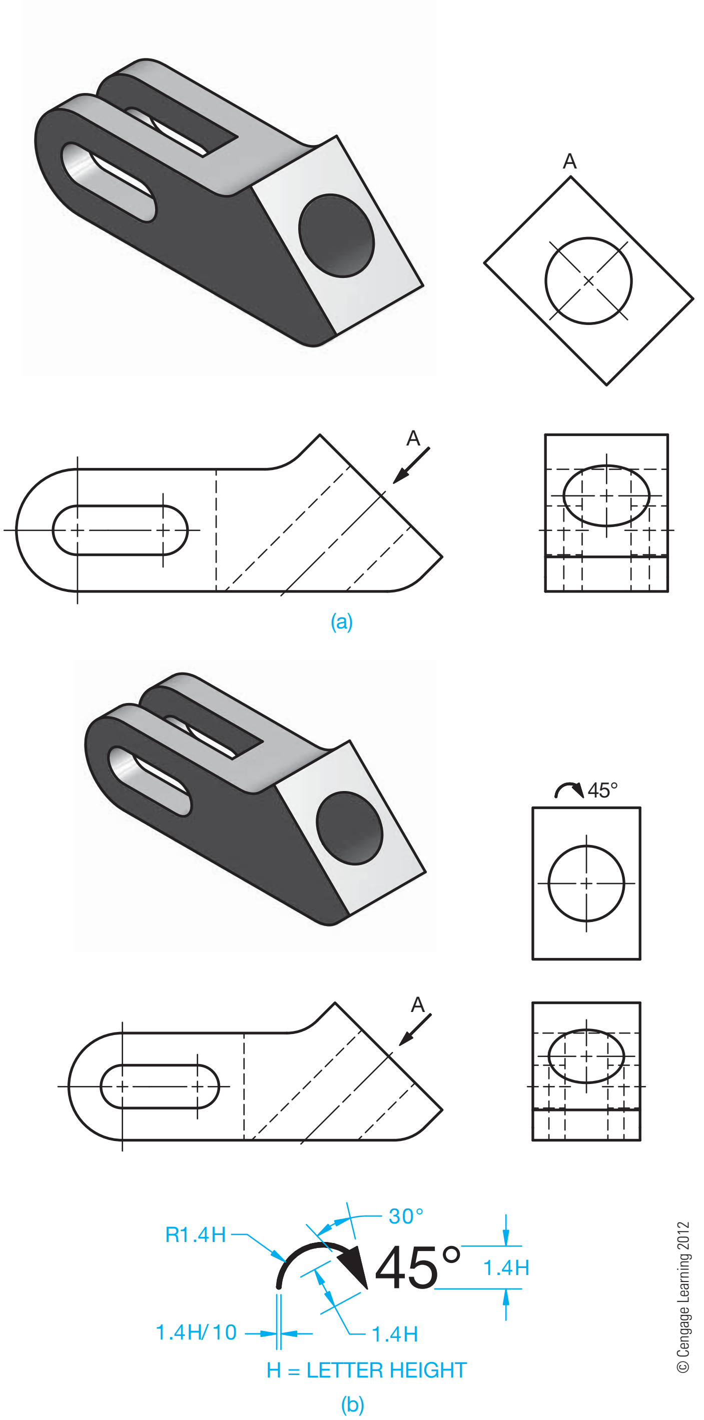


FIGURE 9.18 (a) Establishing an auxiliary view using the arrow method. (b) Establishing a rotated auxiliary view using the arrow method, and the rotation arrow specifications.

SECONDARY AUXILIARY VIEWS

The auxiliary views described are called primary auxiliary views. Primary auxiliary views are views that are adjacent to and aligned with a principal view. In some situations, a feature of an object is in an **oblique** position in relationship to the principal planes of projection. The term *oblique* means that the feature is inclined, slanted, or sloped in the principal view. These inclined or slanting surfaces do not provide an edge view in any of the six possible multiviews. The inclined surface in Figure 9.19 is foreshortened in each view, and an edge view does not exist. From the discussion on primary auxiliary views, you realize that projection must be from an edge view to establish the auxiliary view.

To obtain the true size and shape of the inclined surface in Figure 9.19, a secondary auxiliary view is needed. A secondary auxiliary view is projected from a primary auxiliary view. Secondary auxiliary view is defined as a view that is adjacent to and projected from a primary auxiliary view or from another secondary auxiliary view. The following steps can be used to prepare a secondary auxiliary view:

STEP 1 Only two principal views are necessary to use when creating a secondary auxiliary view because the third principal view does not add additional information. Establish an element in one view that is in true length, as shown in Figure 9.20. Label the corners of the inclined surface and draw a fold line perpendicular to the true-length elements. *Note*: You know a line is in true length when the adjacent view of the line is parallel to the fold line. Look at line 1,3 in Figure 9.20. Line 1,3 is parallel to the fold line in the top view. This makes line 1,3 true length in the front view.

STEP 2 The purpose of this step is to establish a primary auxiliary view that displays the slanted surface as an edge

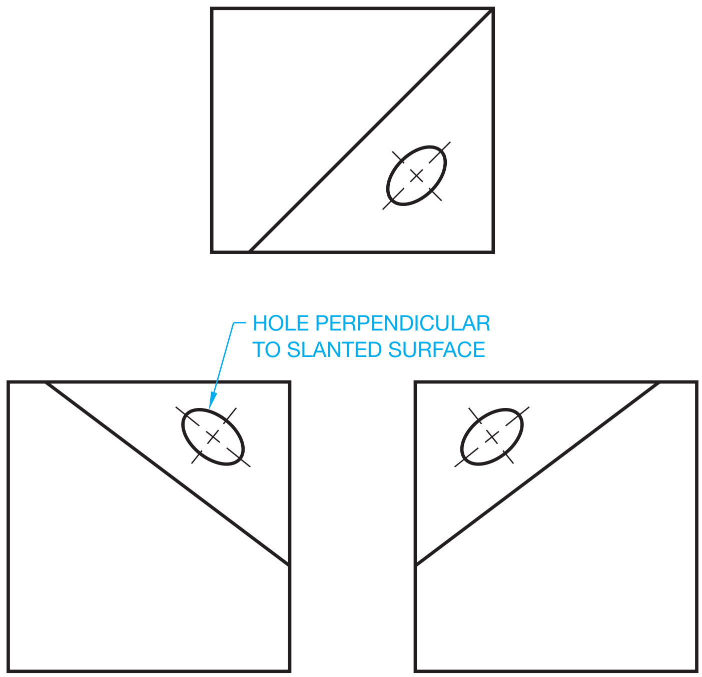


FIGURE 9.19 Oblique surface. There is no edge view in the principal views. This requires a secondary auxiliary view. © *Cengage Learning 2012*

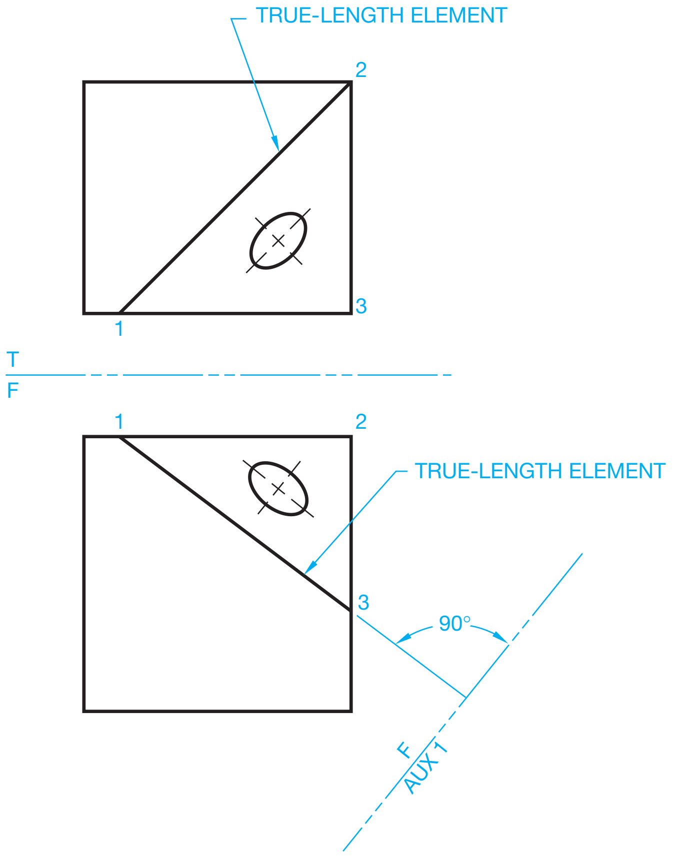


FIGURE 9.20 Step 1: Draw a fold line perpendicular to the true-length element. © *Cengage Learning 2012*

view. Project the slanted surface onto the primary auxiliary plane as shown in Figure 9.21. This results in the inclined surface appearing as an edge view or line in the primary auxiliary view.

STEP 3 Now, with an edge view established, the next step is the same as the normal auxiliary view development. Draw a fold line parallel to the edge view. Project points from the edge view perpendicular to the secondary fold line to establish points for the secondary auxiliary view as shown in Figure 9.22. In Figure 9.22, the primary auxiliary view established corners of the inclined surface as a line or edge view. This edge view is necessary; the perpendicular line of projection for the secondary auxiliary helps establish the true size and shape of the surface.

Using a Primary Auxiliary View in Place of a Principal View

Previously, only the edge view of the inclined surface was shown in the primary auxiliary view. This was because showing the entire object in that view would not have added any clarity to the drawing. The only purpose for the primary auxiliary view was to establish the true geometry in the secondary auxiliary view. In many situations, both the primary and secondary auxiliary views are used to establish the relationship between features of the object. In Figure 9.23, the primary auxiliary view shows the relationship of the inclined feature to the rest of the part, and the secondary auxiliary

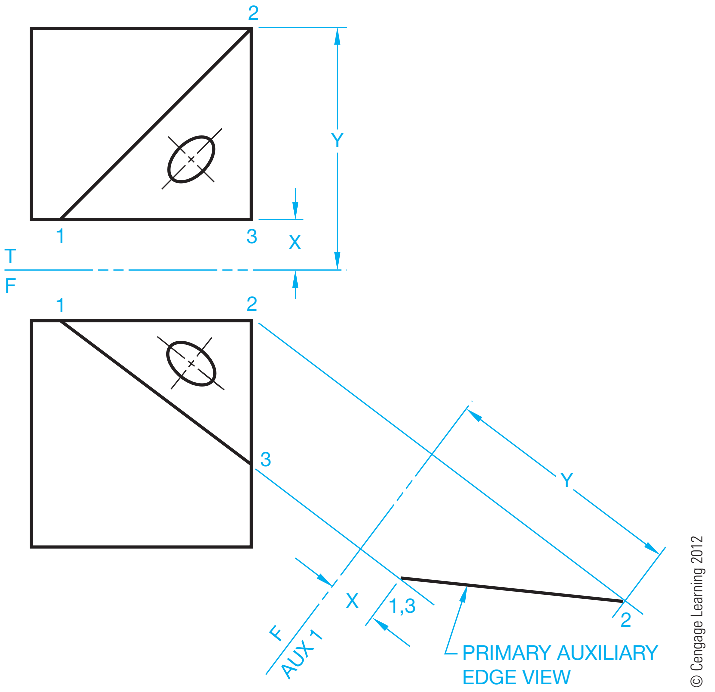


FIGURE 9.21 Step 2: Primary auxiliary edge view of oblique surface.

view shows the true size and shape of the inclined features plus the true location of the holes. In this application, the primary auxiliary view is much like a principal view because it shows height dimensions and the true angle relationship between features on the part.

AUXILIARY VIEW ANALYSIS AND REVIEW

The following is a review covering the features and importance of using multiviews, auxiliary views, and orthographic projection:

- The multiview system, including auxiliary views, is covered in the ASME Y14.3 standard.
- The two internationally accepted view projection systems are third-angle and first-angle projection. Both systems are discussed in this chapter, and third-angle projection is used throughout this textbook.
- Multiview drawings represent the shape of an object using two or more views, and there are six principal views: front, top, right side, left side, bottom, and rear.
- All views are aligned in either third-angle projection or first-angle projection, and the appropriate third- or first-angle projection symbol should be placed on the drawing.
- Adjacent views must be aligned, unless otherwise specified.
- Related views must be aligned, unless otherwise specified.
- There is always one dimension that is the same between adjacent views.
- The front view is normally considered the most important view from which other views are established.
- The number of required views varies, depending on the complexity of the object, and views must be selected to completely describe the shape and features on the object.
- A line in a view is in true length when the line is parallel to the projection plane.

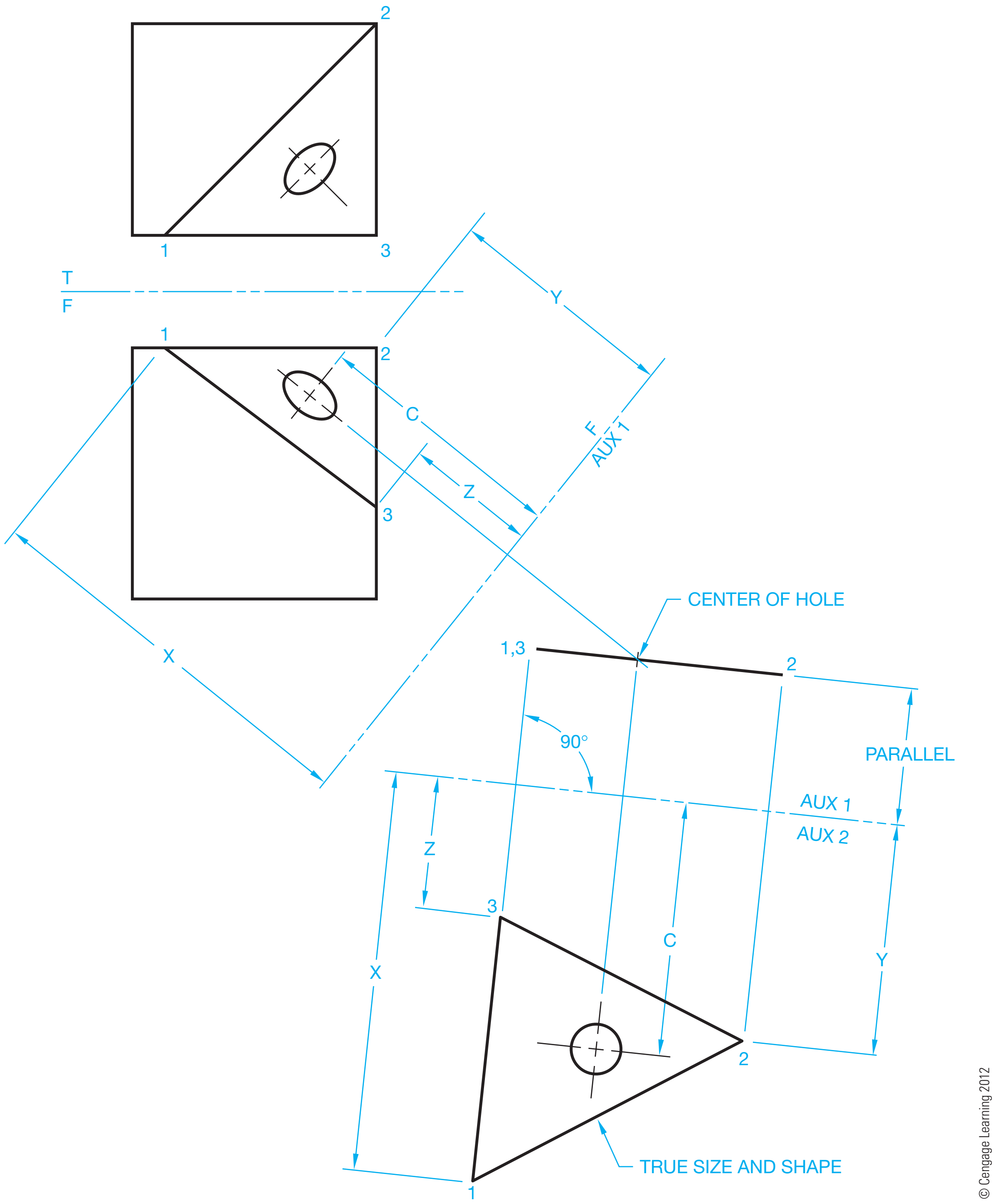


FIGURE 9.22 Step 3: Secondary auxiliary projected from the edge view to get the true size and shape of the oblique surface.

- A surface of a view is in true size and shape when the surface is parallel to the projection plane.
- A line in a view is foreshortened when the line is not parallel to the projection plane.
- A surface of a view is foreshortened when the surface is not parallel to the projection plane.
- Auxiliary views are used to show the true size, shape, and relationship of features of a surface that is not parallel to any of the principal planes of projection.
- A primary auxiliary view is one that is adjacent to and aligned with a principal view.
- A secondary auxiliary view is one that is adjacent to and aligned with a primary auxiliary view or with another secondary auxiliary view.
- Additional view placement options are discussed in this chapter and in Chapter 8 and include: removed views, rotated views, and detail views. Use of these options should be confirmed with your school or company practices.

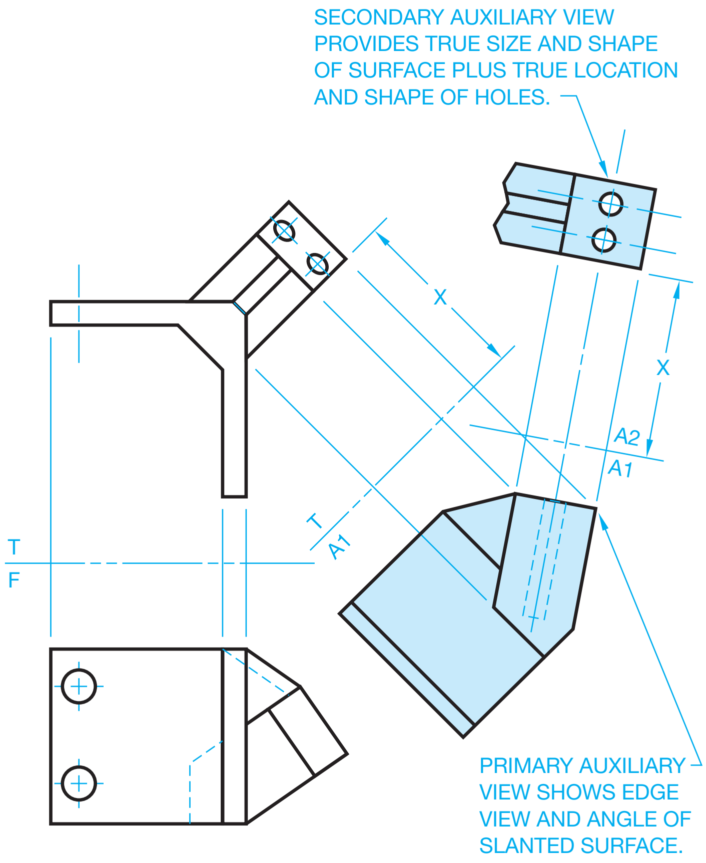


FIGURE 9.23 Creating primary and secondary auxiliary views. *©Cengage Learning 2012*

DESCRIPTIVE GEOMETRY

Descriptive geometry, covered in detail in Student CD, is used for determining issues such as finding the true lengths of lines, the end view of a line, the true size and shape of a surface or plane, the angle between two lines, the angle between two planes, the intersection between two planes, and the intersection between a cone or a cylinder and a plane. Descriptive geometry problems are solved graphically by projecting points onto selected adjacent projection planes in an imaginary projection system. The multiview and auxiliary view concepts you learned in Chapter 8 and in this chapter serve as a basis for further study of descriptive geometry concepts. What you have learned in these two chapters, coupled with what you will learn in the descriptive geometry content, will help you solve additional drafting problems as you study advanced chapters covering specialty drafting fields and problems you encounter in industry.

Descriptive Geometry

For complete information about Descriptive Geometry, go to the Student CD, select **Reference Material**, and then **Descriptive Geometry I** and **Descriptive Geometry II**.

AUXILIARY VIEW LAYOUT

Working with auxiliary views is a little more complex than working with the normal multiviews. The auxiliary view is often difficult to place in relationship to the other views. Sheet size requirements can cause the auxiliary view to interfere with other views. Whenever possible, it is best to project the auxiliary view directly from the inclined surface with one projection line connecting the inclined surface to the auxiliary view. This arrangement makes it easier for the reader to correctly interpret the relationship of the views. This method is shown in the layout steps provided in Figure 9.13 through Figure 9.15.

When drawing space is limited, it is possible to use the viewing-plane method or the rotated view method to display the auxiliary view. These techniques are shown in Figure 9.9 through Figure 9.11. The advantage of the viewing-plane method is that it allows you to place the auxiliary view in any convenient place on the drawing. Multiple auxiliary views should be placed in a group arranged from right to left and from top to bottom on the drawing. A poor practice sometimes used by entry-level drafters is to place viewing planes all over the drawing and shift views from their normal position. This practice should be avoided because the normal multiview projection is always best. You should follow the layout procedure described in Chapter 8 for multiviews and for auxiliary views described in this chapter.

The following steps summarized creating a multiview and an auxiliary view layout:

- Select and sketch the front view.
- Select and sketch the other principal views in proper relationship to the front view, eliminating any unnecessary views.
- Sketch the auxiliary view or views in their proper positions.
- Establish the sheet size and the working area to be used.
- Determine the approximate total drawing area.
- Lay out the views using construction lines.
- Complete the formal drawing.

Instruction on the development of views often focuses on the use of three views, such as a front, top, and side view or a front, top, and auxiliary view. Although this view orientation is common, the actual view selection depends entirely on the part you are drawing. Many parts can require a number of views that can include several multiviews and an auxiliary view. The combination of views can even include a sectional view. Section views are covered in detail in Chapter 12. Spend some time looking at as many real-world drawings as you can find. You may discover that some actual industry drawing could be done in a different manner and that you might have ideas for improving the way drawings are done. This is your challenge as you begin to create your own drawings. The actual industry drawing shown in Figure 9.24 shows a front view, top view, right-side view, VIEW A–A created with a viewing plane, a broken-out sectional view, and a partial auxiliary view projected from the sectional view. This example demonstrates the complexity of some drawings.

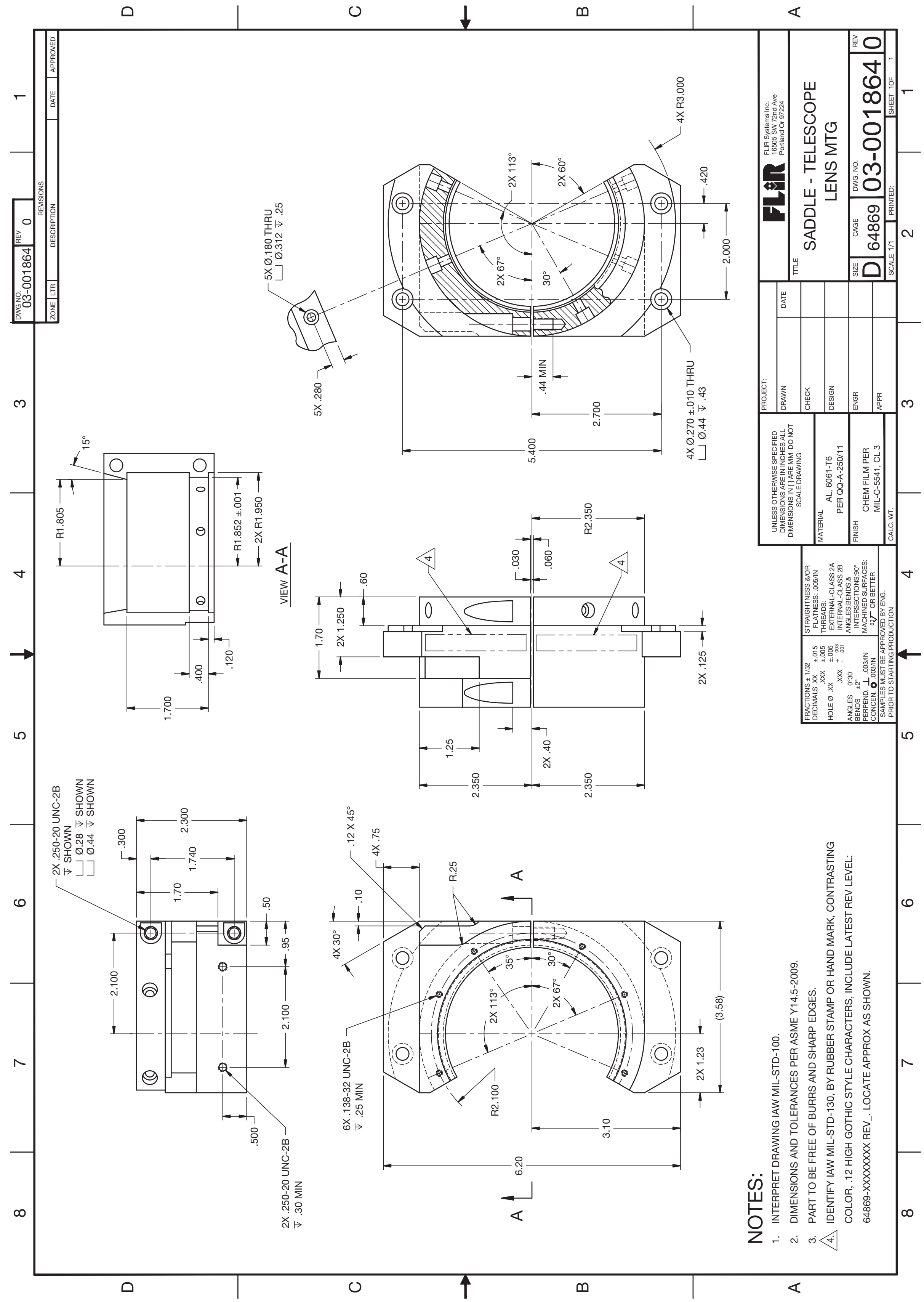
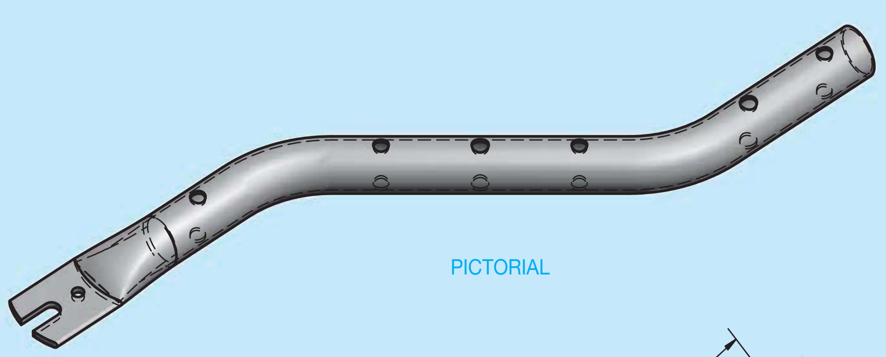


FIGURE 9.24 A complex part displayed on the drawing using several carefully selected views including a front, top, and right-side view; a sectional view; a view created from a viewing plane; a sectional view; and an auxiliary view. *Courtesy FLIR Systems*

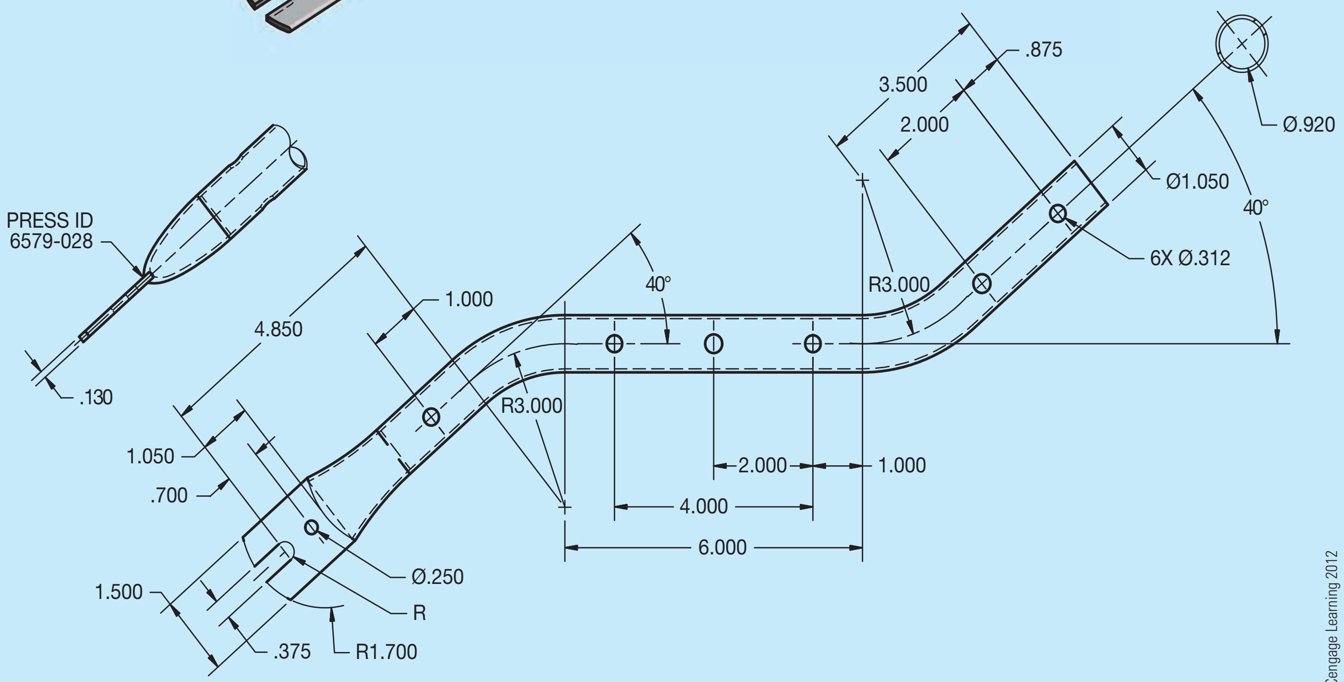
DRAWING ACCURACY

One important aspect of CADD technology is accuracy. Multiview and auxiliary view drawings produced with CADD should be perfect if you use appropriate CADD techniques and follow correct drafting standards throughout the drawing process. The reason for high accuracy involves the capabilities of computer hardware and software and the fact that the computer displays the mathematical counterpart of the true geometry. Drawing views are a representation of the mathematical coordinates of the design problem. Therefore, the accuracy potential of the computer controls drawing accuracy.

Figure 9.25 shows an example of a drawing of a tubular mainframe part. A front view and two partial auxiliary views represent the part completely. CADD offers tools and options that allow you to construct the geometry of the front view quickly and accurately. You can then easily project the auxiliary views from the inclined surfaces using a viewing plane exactly perpendicular to the inclined surfaces. The final step is to add dimensions associated with view objects. The computer stores data about each object. Any changes you make to the drawing update in the associated views and dimensions.



PICTORIAL



DRAWING

FIGURE 9.25 An example of a part with a front view and two auxiliary views.

AUXILIARY VIEW CONSTRUCTION

The process of construction auxiliary views using 2-D drafting software is similar to drawing principal multiviews. The main difference is you must account for a viewing plane that is perpendicular to inclined surfaces. Most 2-D drafting applications include functions for accurately defining object points using coordinate point entry methods and basic drawing aids such as grid lines and grid snaps. You can also develop auxiliary views using common construction geometry or specific software drawing aids, such as AutoCAD's object snap and AutoTrack tools.

Figure 9.26 shows an example of using on-screen grid rotated to the same angle as the inclined surface from which the auxiliary view projects. The grid is a drawing aid for development purposes only and may display as dots or as the lines shown. The grid does not plot and can be turned off when no longer needed. Figure 9.27 shows another method of projecting the auxiliary view. This example uses infinite length construction lines drawn perpendicular to the inclined surface. Construction lines are objects in the drawing and can be reused for future

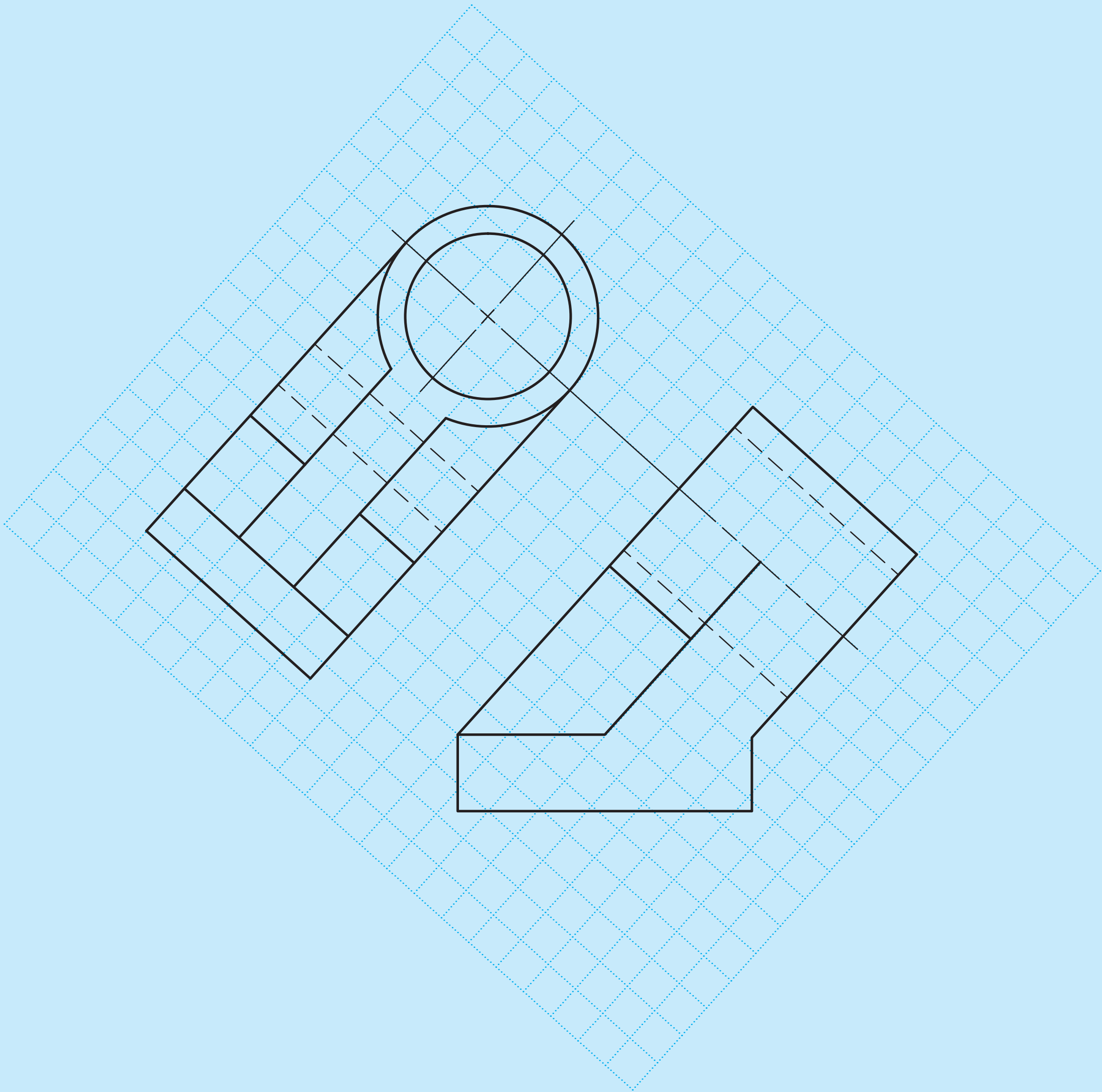


FIGURE 9.26 Using the rotated on-screen grid to help draw the auxiliary view.

(Continued)

CADD APPLICATIONS 2-D

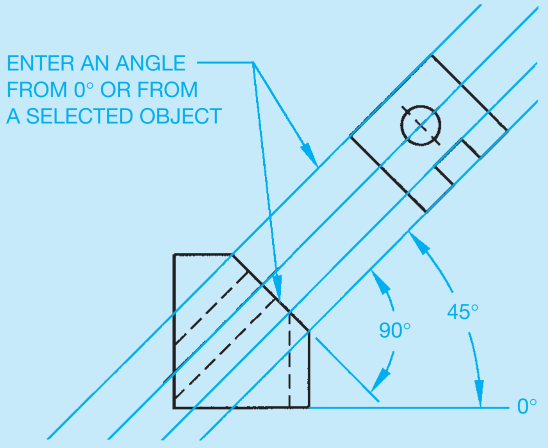


FIGURE 9.27 Laying out an auxiliary view using construction lines perpendicular to the inclined surface. © *Cengage Learning 2012*

layout, hidden by freezing or turning off a dedicated construction layer, or removed using a DELETE or ERASE command. Several other techniques for constructing auxiliary views may be possible, depending on the software. For example, AutoCAD's object snap and AutoTrack tracking allow you to locate points on the auxiliary view by referencing points on the existing view, perpendicular to the inclined surface. This process mimics accurate construction lines, without you having to spend time drawing additional objects.

CADD APPLICATIONS 3-D

AUXILIARY VIEWS

The parametric 2-D drawing capabilities of some 3-D solid modeling programs allow you to easily produce a variety of drawing views, including auxiliary views. Tools such as AUXILIARY VIEW allow you to create an auxiliary view by referencing an existing drawing view to parametrically associate a view with the model (see Figure 9.28). Using a tool like AUXILIARY VIEW typically involves selecting an existing drawing view with the inclined surface from which the auxiliary view will project and then picking the edge of the inclined surface and specifying a location for the auxiliary view. You can also choose to add auxiliary view information, such as a view label, by selecting the appropriate options. Often when you create an auxiliary view, all object geometry located on and beyond the selected inclined surface projects onto the auxiliary view plane. This means that you may be required to hide or turn off the visibility of certain, foreshortened edges to create a partial auxiliary view as shown in Figure 9.28.

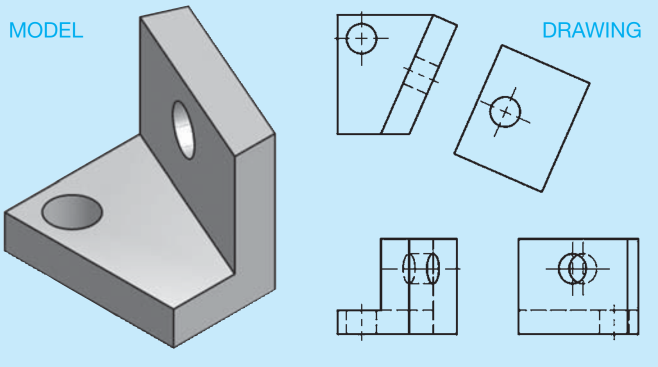


FIGURE 9.28 CADD tools such as AUXILIARY VIEW allow you to create an auxiliary view by referencing an existing drawing view, which parametrically associates a view with the model. © *Cengage Learning 2012*

PROFESSIONAL PERSPECTIVE

For many people, one of the most difficult aspects of engineering drafting is the need to visualize two-dimensional views. This special ability is natural for some, whereas others must carefully analyze every part of a multiview and auxiliary view drawing in order to fully visualize the product. Ideally, you should be able to look at the views of an object and readily formulate a pictorial representation in your mind. The main reason that multiviews are aligned is to assist in the visualization and interpretation process. The front view is the most important view, and that is why it contains the most significant features. As you look at the front view, you should be able to gain a lot of information about the object then visually project from the front view to other views to gain an understanding of the entire product.

It is up to you to select the best views to completely describe the object. Too few views make the object difficult or impossible to interpret, and too many views make the drawing too complex and also waste valuable drafting time. If you follow the guidelines set up in this chapter, you should be able to successfully complete the task. Remember, always begin with a sketch. With the sketch, you can quickly determine view arrangement and spacing. Without the preliminary sketch, you might use a lot of drafting time and end up discovering that the layout does not work as you expected.

MATH APPLICATIONS

PROJECTED AREA

Problem: Suppose the steel plate in the shape of an ellipse with an area of 65.98 ft^2 (from the Math Application in Chapter 8) is set at a 60° angle on the ground. With the sun overhead, what is the area of the *shadow* of the plate on the ground? (See Figure 9.29.)

Solution: The shadow's area is called the *projected area* in math. It is found by multiplying the true area by the *cosine* of the inclined angle. Using a calculator, cos 60° = .5, so the area of the shadow is 65.98 × .5 = 32.99 or 33 ft^2. The principle of multiplying true area by cosine to obtain projected area applies to all 2-D shapes. Math Applications in later chapters further explore right triangles and trigonometry functions, such as cosine.

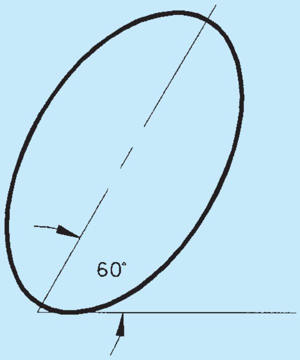


FIGURE 9.29 Tilted ellipse. *© Cengage Learning 2012*

WEB SITE RESEARCH

Use the following Web sites as a resource to help find more information related to engineering drawing and design and the content of this chapter.

Address	Company, Product, or Service
www.asme.org	American Society of Mechanical Engineers (ASME)
www.iso.org	International Organization for Standardization
www.adda.org	American Design Drafting Association and American Digital Design Association (ADDA International)

Chapter 9

Chapter 9 Auxiliary Views Test

To access the Chapter 9 test, go to the Student CD, select **Chapter Tests and Problems**, and then **Chapter 9**. Answer the questions with short, complete statements, sketches, or drawings as needed. Confirm the preferred submittal process with your instructor.

Chapter 9 Auxiliary Views Problems

Parts 1, 2, and 3: Problems 9.1 Through 9.14

To access the Chapter 9 problems, go to the Student CD, select **Chapter Tests and Problems** and **Chapter 9**, and then open the problem of your choice or as assigned by your instructor. Solve the problems using the instructions provided on the CD, unless otherwise specified by your instructor.

Part 4: Problem 9.15

This problem provides you with dimensioned pictorial views and a proposed start for your multiview and auxiliary view layout. Draw the required multiviews and auxiliary views. Use the given dimensions to create your final drawing. Set up your drawings with a properly sized sheet, border, and sheet block. Properly complete the information in the title block. Do not draw the pictorial view unless required by your instructor. Do not draw the dimensions.

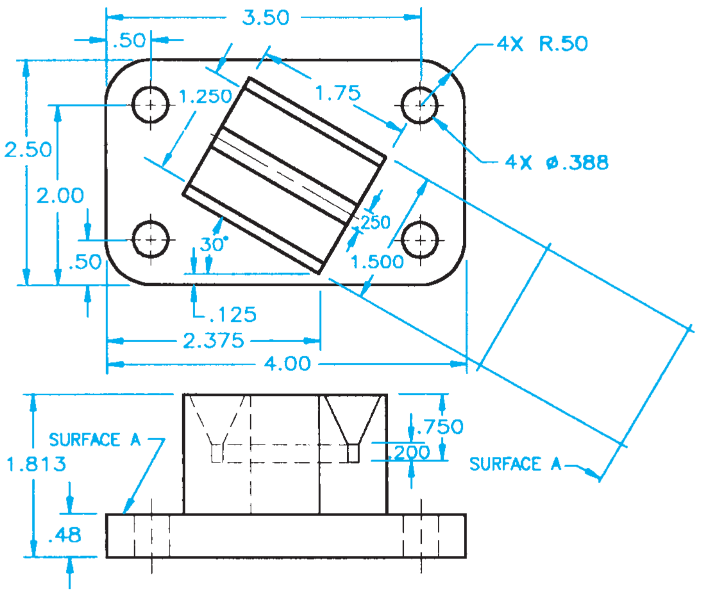
Drafting Templates

To access CADD template files with predefined drafting settings, go to the Student CD, select **Drafting Templates,** and then the appropriate template file. Use the templates to create new designs, as a resource for drawing and model content, or for inspiration when developing your own templates. The ASME-Inch and ASME-Metric drafting templates follow ASME, ISO, and related mechanical drafting standards. Drawing templates include standard sheet sizes and formats and a variety of appropriate drawing settings and content. You can also use a utility such as the AutoCAD DesignCenter to add content from the drawing templates to your own drawings and templates. Consult with your instructor to determine which template drawing and drawing content to use.

PROBLEM 9.15 **Primary auxiliary view (in.)**

Title: Angle V-block

Material: SAE 4320



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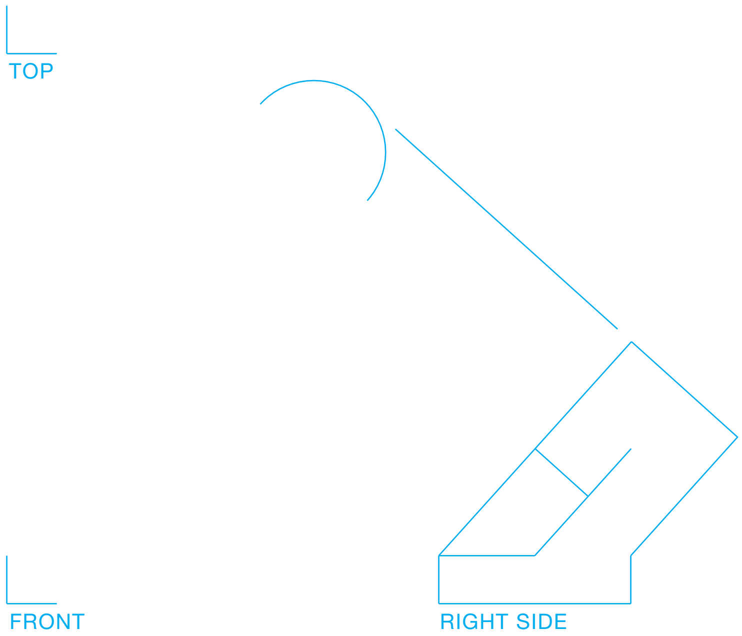
Part 5: Problems 9.16 Through 9.24

The following problems provide you with pictorial views that contain dimensions and a recommended view layout. Draw the views. The pictorial views are provided to aid in visualization and to display the dimensions. You do not need to draw the pictorial view. Use the given dimensions to create your final drawing. Set up your drawings with a properly sized sheet, border, and sheet block. Properly complete the information in the title block. Do not draw the dimensions.

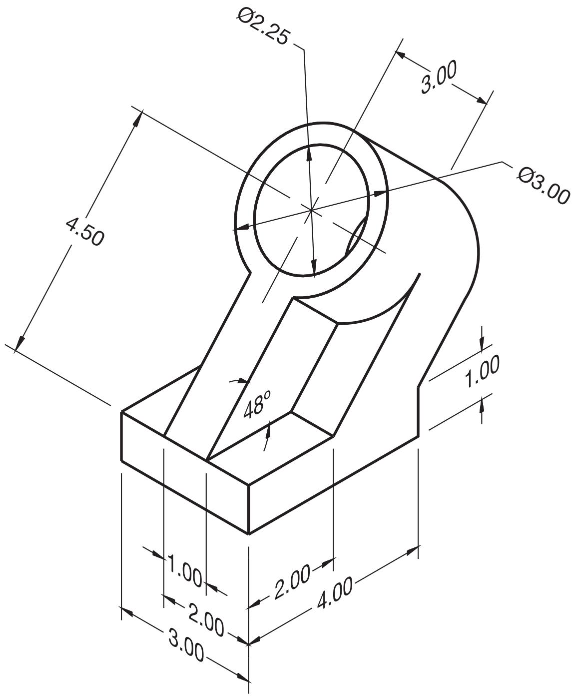
PROBLEM 9.16 **Primary auxiliary view (in.)**

Title: Cylinder Support

Material: Cast iron



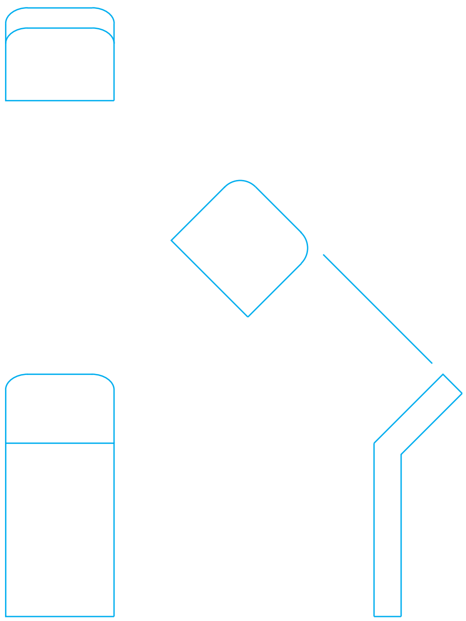
SUGGESTED VIEW LAYOUT



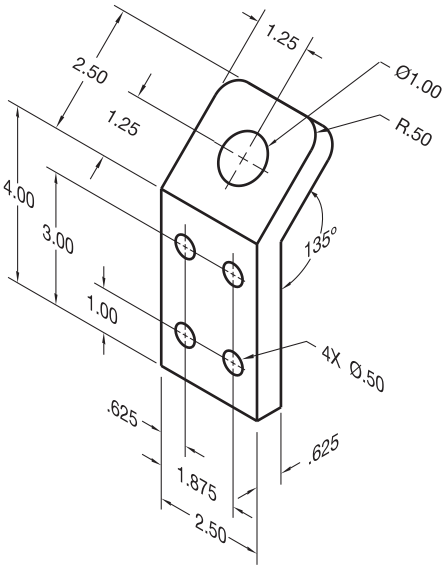
PROBLEM 9.17 **Primary auxiliary view (in.)**

Title: 135 Bracket

Material: Aluminum



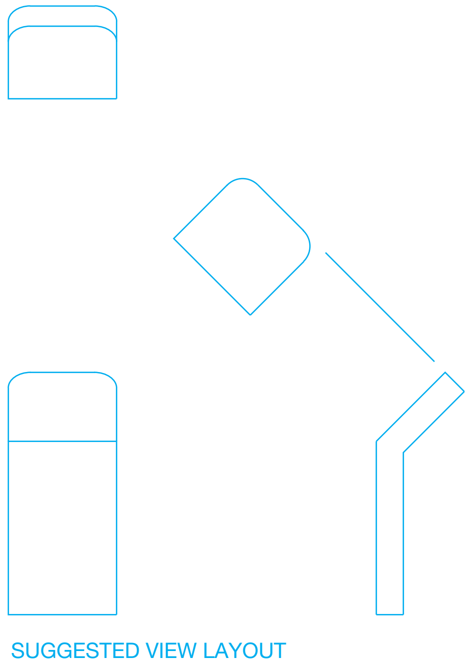
SUGGESTED VIEW LAYOUT

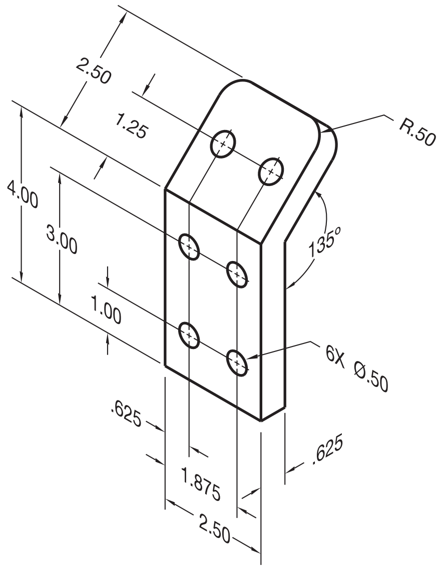


PROBLEM 9.18 Primary auxiliary view (in.)

Title: 135-1 Bracket

Material: Aluminum

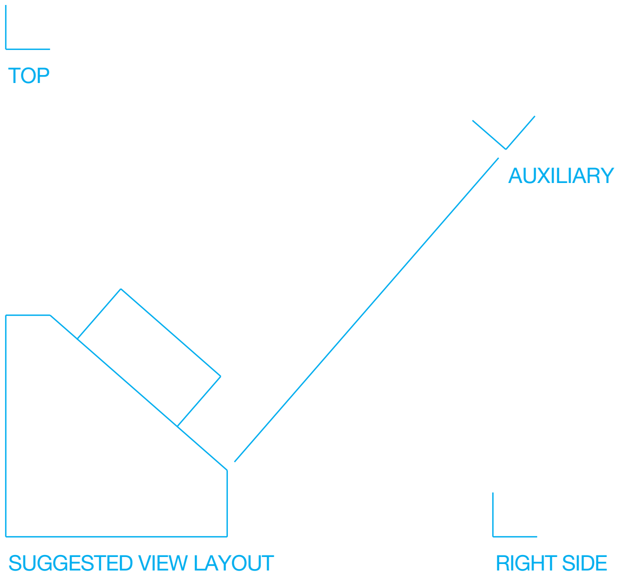


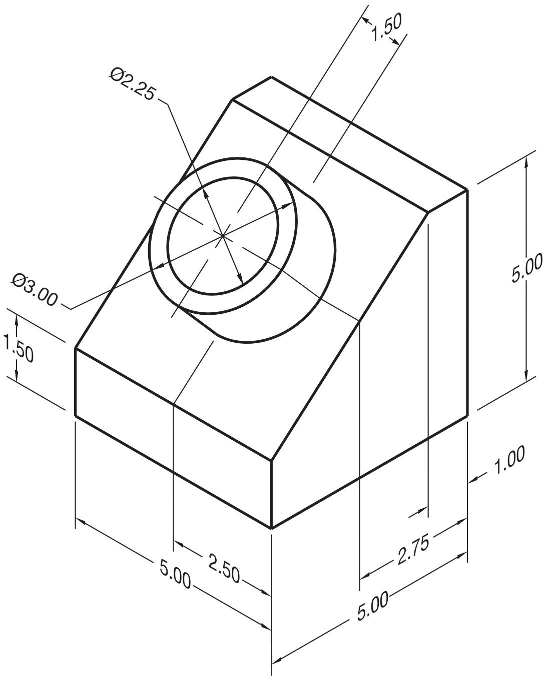


PROBLEM 9.19 Primary auxiliary view (in.)

Title: Support Base

Material: Cast aluminum

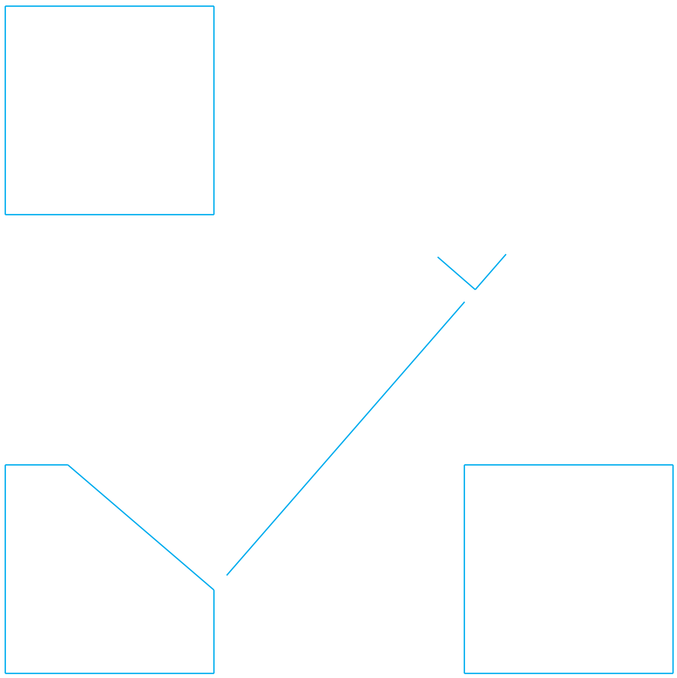




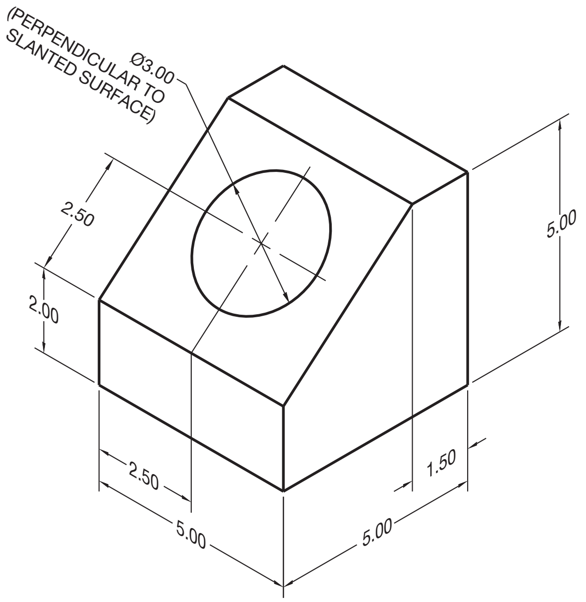
PROBLEM 9.20 **Primary auxiliary view (in.)**

Title: Shaft Support

Material: SAE 1020



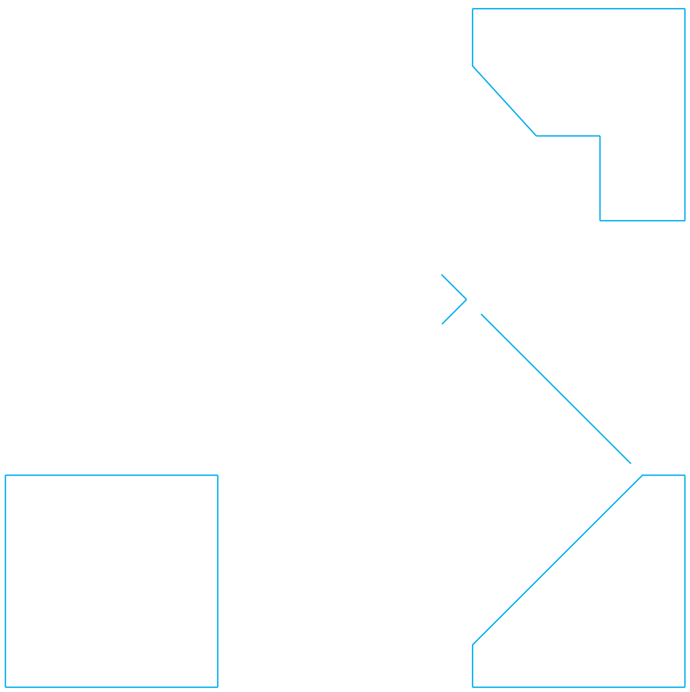
SUGGESTED VIEW LAYOUT



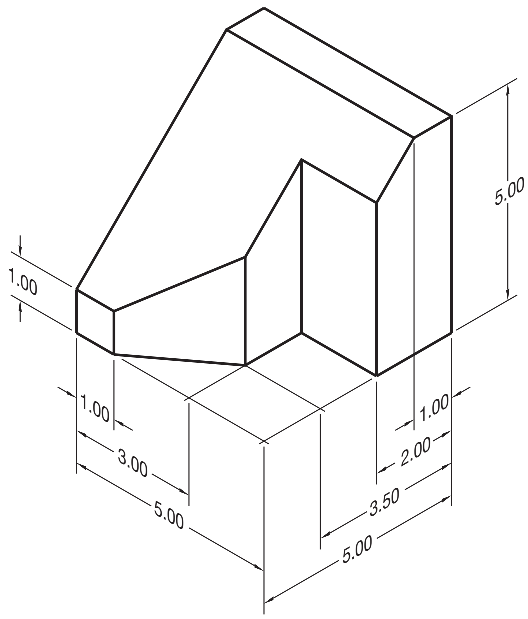
PROBLEM 9.21 **Primary auxiliary view (in.)**

Title: Spacer

Material: Cast iron



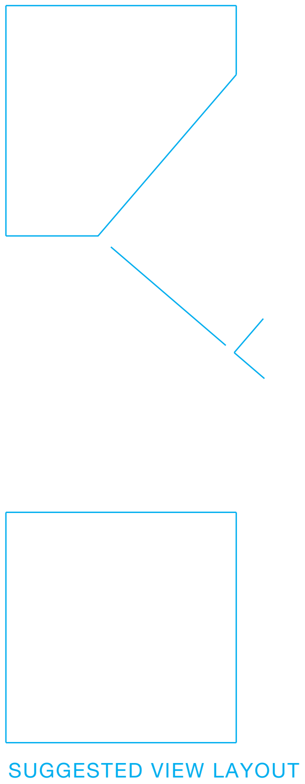
SUGGESTED VIEW LAYOUT

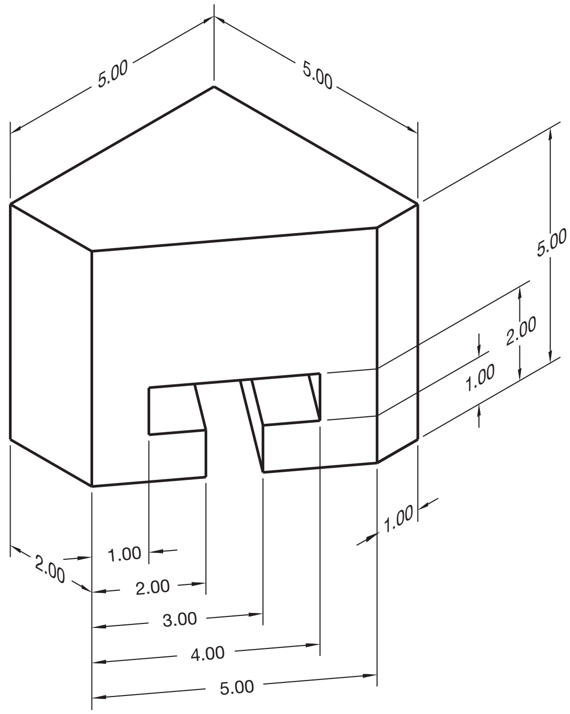


PROBLEM 9.22 Primary auxiliary view (in.)

Title: T-Block

Material: SAE 4320

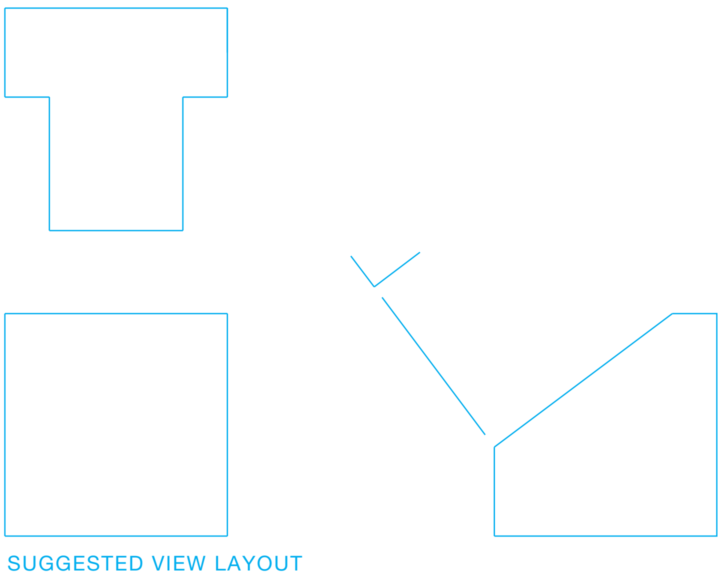


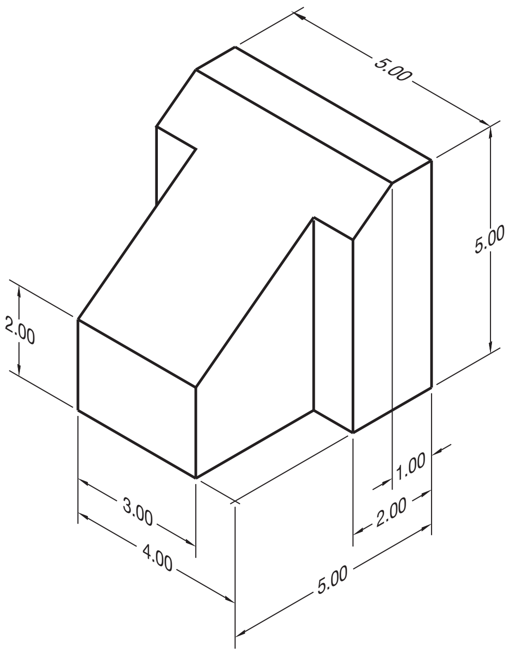


PROBLEM 9.23 Primary auxiliary view (in.)

Title: T-Wedge

Material: Mild steel

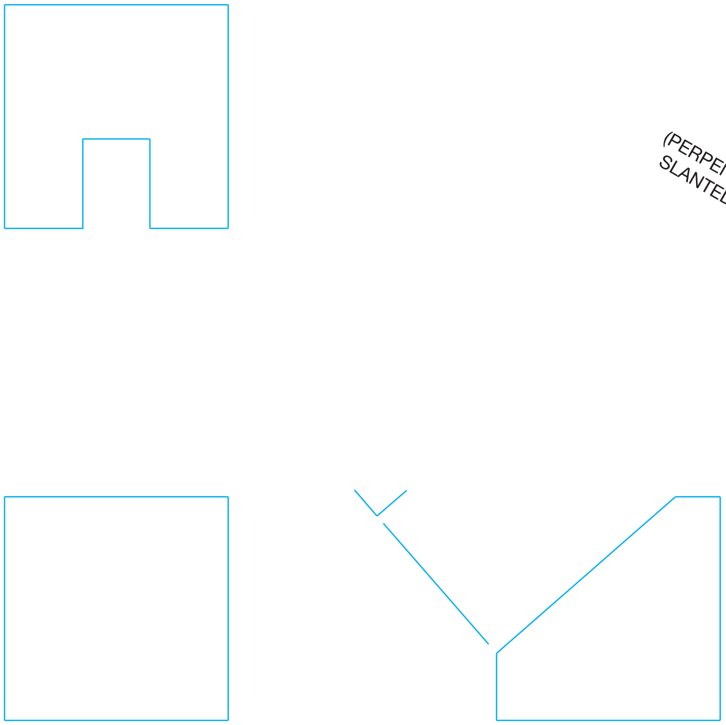




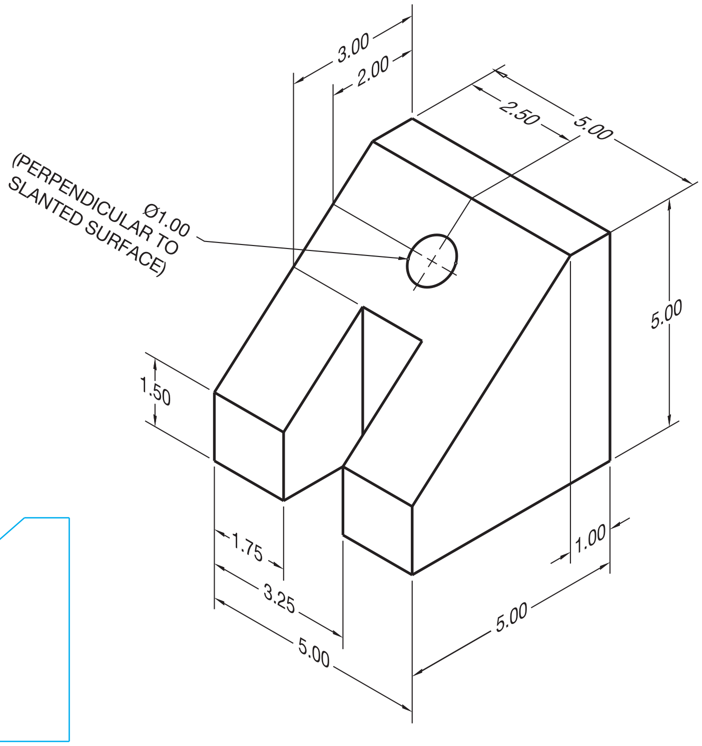
PROBLEM 9.24 **Primary auxiliary view (in.)**

Title: Brace

Material: Cast iron



SUGGESTED VIEW LAYOUT



Part 6: Problems 9.25 Through 9.37

To access the Chapter 9 problems, go to the Student CD, select **Chapter Tests and Problems** and **Chapter 9**, and then open the problem of your choice or as assigned by your instructor. Solve the problems using the instructions provided on the CD, unless otherwise specified by your instructor.

Part 7: Problems 9.38 and 9.39

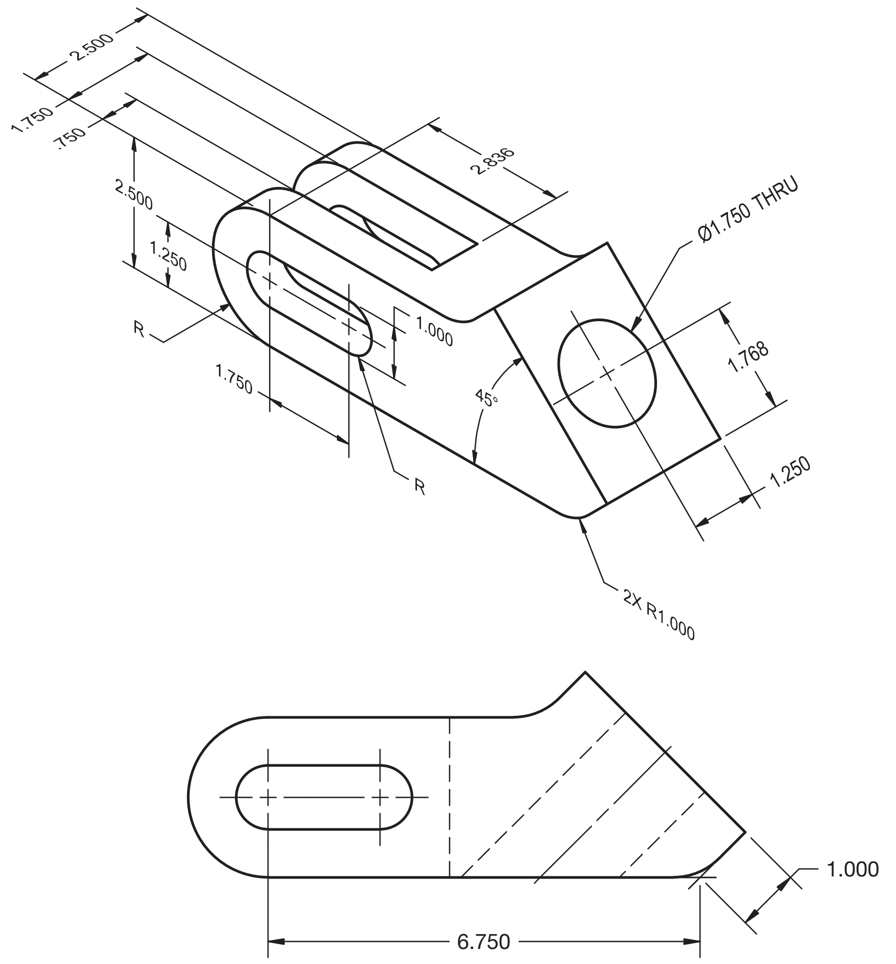
The following problems provide you with pictorial views that contain dimensions and a recommended view layout. Draw the views. The pictorial views are provided to aid in visualization and to display the dimensions. You do not need to draw the pictorial view. Use the given dimensions to create your final drawing. Set up your drawings with a properly sized sheet, border, and sheet block. Properly complete the information in the title block. Do not draw the dimensions.

PROBLEM 9.38 **Rotated primary auxiliary view (in.)**

Title: Coupler

Material: Cast iron

Draw the required auxiliary view using the viewing-plane line rotation method.



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PROBLEM 9.39 **Rotated primary auxiliary view (in.)**

Title: Coupler

Material: Cast iron

Given the same part provided in Problem 9.38, draw the required auxiliary view using the arrow and rotation arrow method.

Math Problems

Part 8: Problems 9.40 Through 9.49

To access the Chapter 9 problems, go to the Student CD, select **Chapter Tests and Problems** and **Chapter 9**, and then open the math problem of your choice or as assigned by your instructor. Solve the problems using the instructions provided on the CD, unless otherwise specified by your instructor.