Pictorial Drawings

Learning Objectives

After studying this chapter, you will be able to:

- List the three basic types of pictorial drawings and explain the purpose of each.
- Explain the principles of axonometric projection.
- Draw isometric, dimetric, and trimetric views.
- Draw oblique views.
- Draw one-point and two-point perspective views.
- Describe how pictorial views are created in CAD drafting.

Technical Terms

Axonometric projection
Cabinet oblique
Cavalier oblique
Dimetric projection
Foreshortened
General oblique
Ground line
Horizon line
Isometric
Isometric axes
Isometric grid
Isometric lines
Isometric planes
Isometric projection
Isometric snap
Isoplanes
Measuring point system
Nonisometric lines
Normal surfaces
Oblique projection
One-point perspective
Perspective drawing
Perspective grid
Pictorial drawing
Picture plane
Station point
Trimetric projection
Two-point perspective
Vanishing points
Visual rays

A *pictorial drawing* is a realistic, three-dimensional representation showing the width, height, and depth of an object. Pictorial drawings are more "lifelike" than multiview (orthographic) drawings. These drawings are particularly useful for a "nontechnical" person who needs information from a drawing.

Pictorial drawings are used to supplement multiview drawings. A pictorial drawing should clarify information contained in a multiview. Pictorials are sometimes used as a substitute for a multiview drawing. If the task to be performed is not highly complex, a pictorial view might convey all of the required information by itself. In many cases, a pictorial drawing of an assembly provides a better description than a multiview drawing of the same part, **Figure 11-1**.

Pictorial drawings are widely used for assembly drawings, piping diagrams, service and repair manuals, sales catalogs, and technical training manuals. Pictorials are also used by the general public in the assembly of prefabricated furniture, swing sets, and "do-it-yourself" kits.

Types of Pictorial Projections

There are three basic types of pictorial projections used in drafting: axonometric, oblique, and perspective, **Figure 11-2**. Under each of these three groupings are several subtypes. This chapter discusses the various types of pictorials and the techniques used in drawing them. Recommended methods of dimensioning and sectioning are also covered.

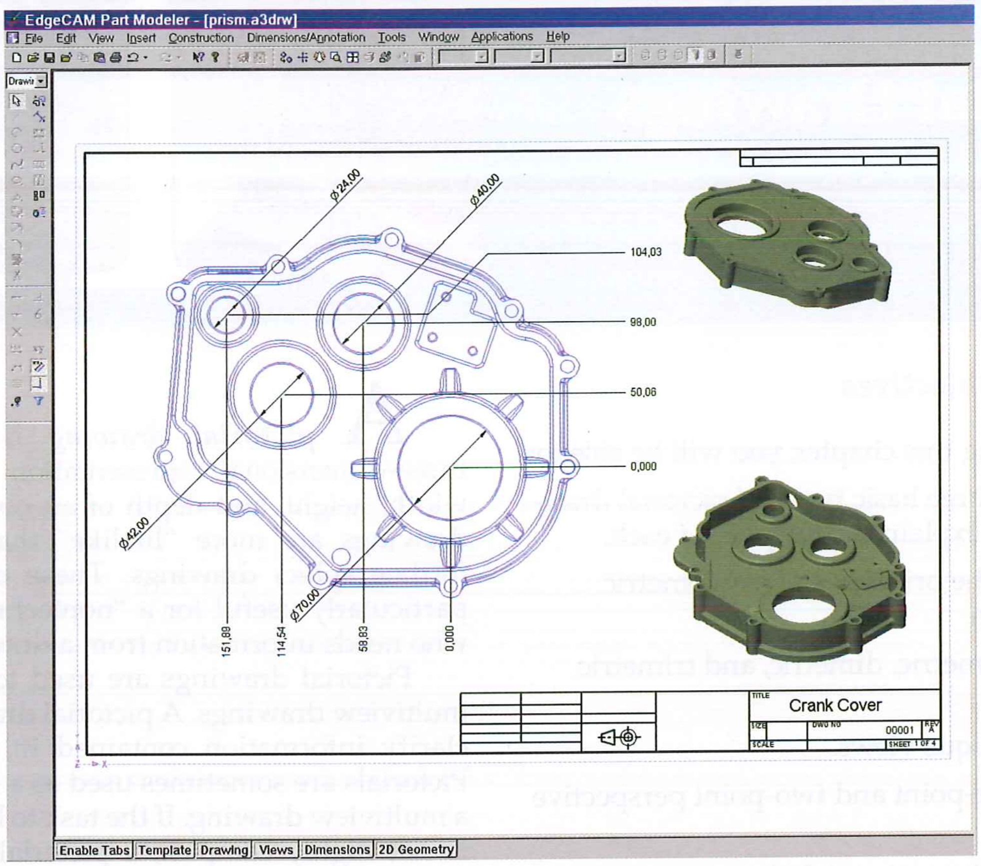


Figure 11-1. Pictorial drawings help clarify the assembly of parts. (EdgeCAM/Pathtrace)

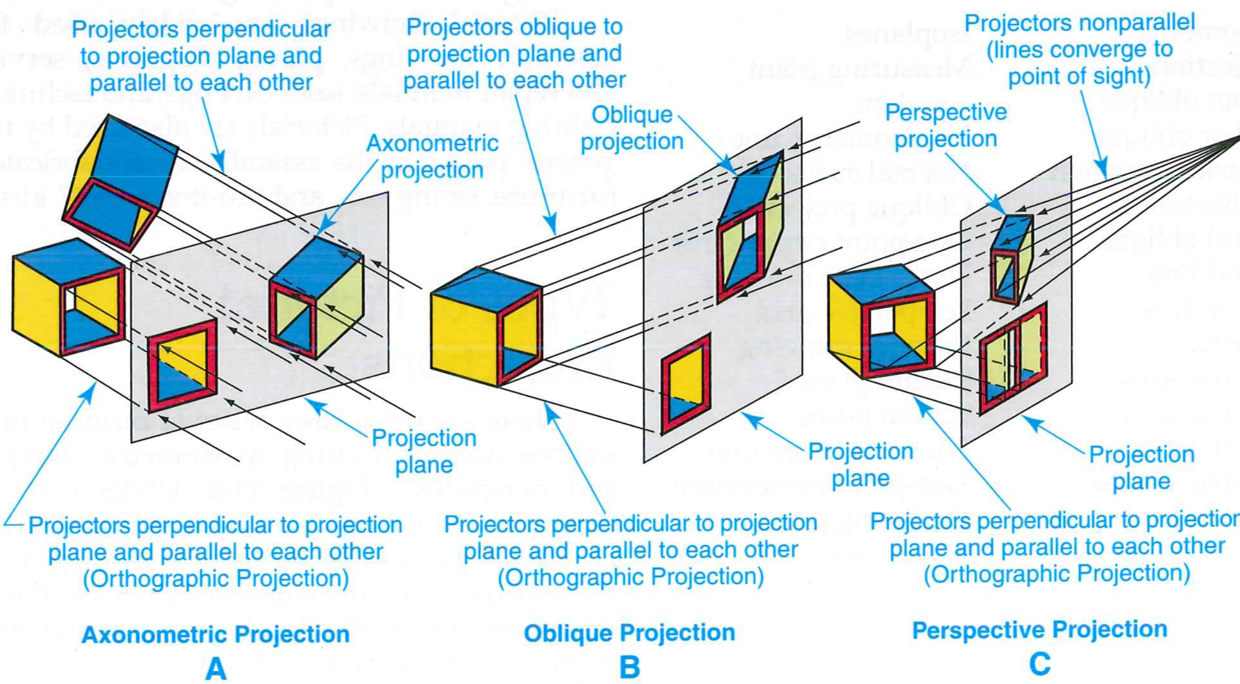


Figure 11-2. Types of pictorial projections. A—Axonometric. B—Oblique. C—Perspective. (American National Standards Institute)

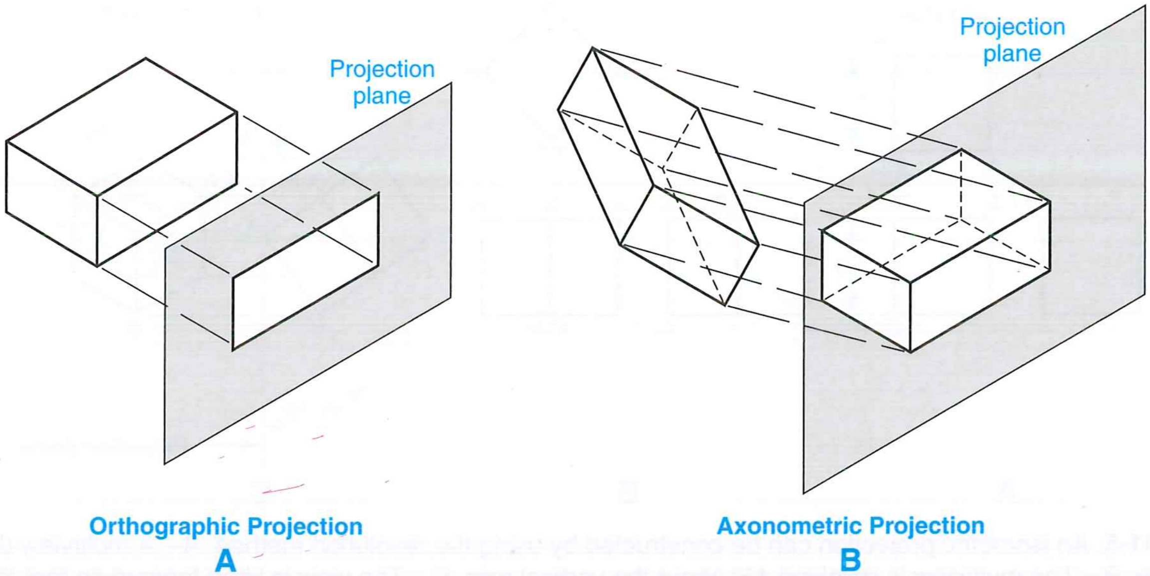


Figure 11-3. In both axonometric projection and orthographic projection, the lines of sight are perpendicular to the projection plane. However, in axonometric projection, the object faces are inclined to the projection plane. A—In an orthographic projection, the front face of the object is perpendicular to the projection plane. B—In an axonometric projection, the object faces are all inclined to the projection plane.

Axonometric Projection

In *axonometric projection,* the lines of sight (projectors) are perpendicular to the plane of projection. In this sense, axonometric projection is similar to orthographic projection, **Figure 11-3.** However, while the lines of sight of the axonometric projection are perpendicular to the plane of projection, the three faces of the object are all inclined to the plane of projection. This gives the projection a three-dimensional pictorial effect. The principal axes of an axonometric projection can be at any angle, except 90°.

There are three types of axonometric projections: isometric, dimetric, and trimetric, **Figure 11-4.** There are two differences between the three types of axonometric projections. They differ in the angles made by the faces with the plane of projection. Also, they differ in the angles made by the principal axes.

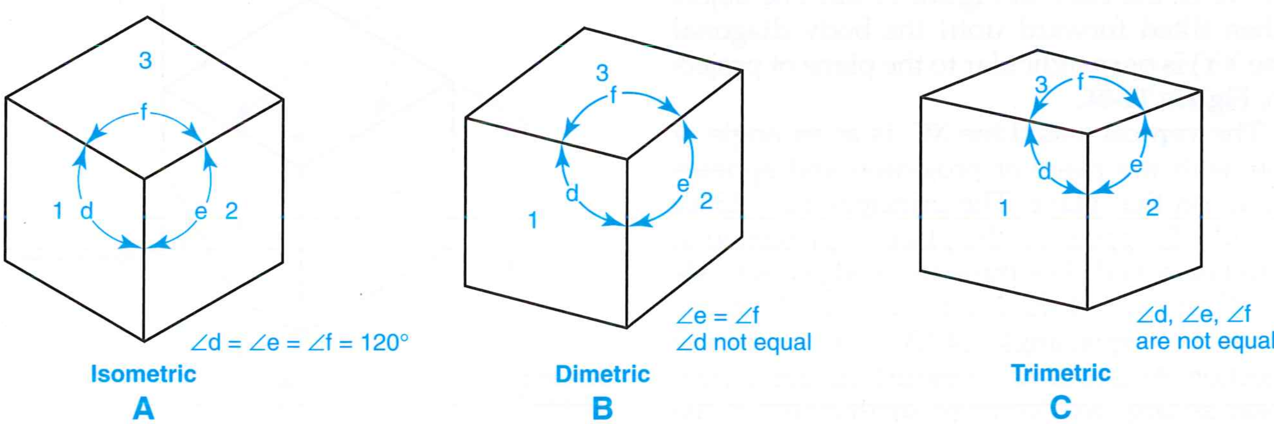


Figure 11-4. The three types of axonometric projections. A—In an isometric projection, all three principal faces (1, 2, and 3) of the object are equally inclined to the projection plane. Also, all three axes make equal angles (d, e, and f) with each other. B—In a dimetric projection, only two faces (1 and 3) are equally inclined to the projection plane. Also, only two axes make equal angles (e and f) with each other. C—In a trimetric projection, none of the three faces (1, 2, or 3) make equal angles with the projection plane. In addition, none of the axes make equal angles (d, e, or f) with each other.

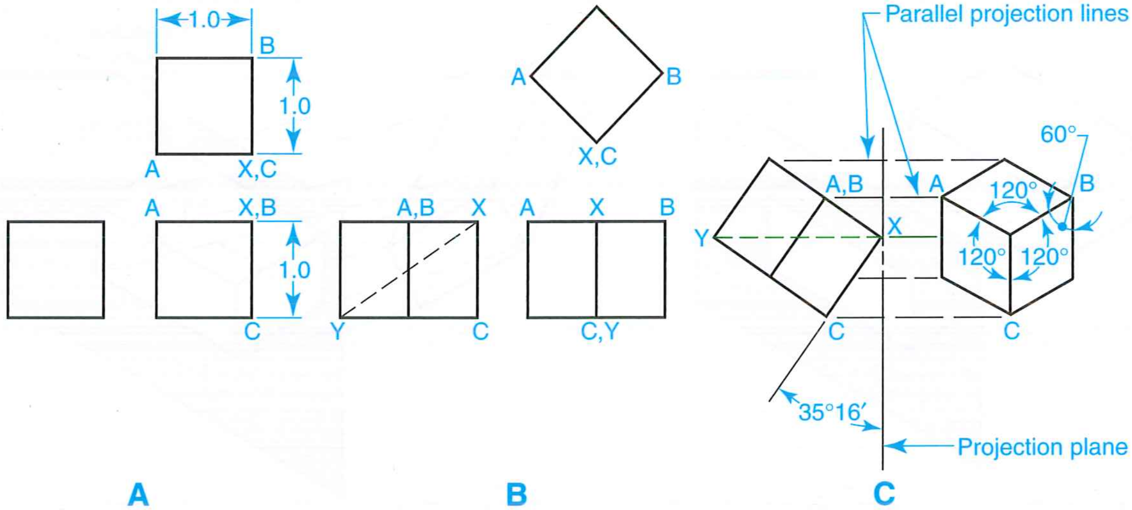


Figure 11-5. An isometric projection can be constructed by using the revolution method. A—A multiview drawing of a cube. B—The multiview is revolved 45° about the vertical axis. C—The view is tilted forward so that the body diagonal is perpendicular to the projection plane and the vertical axis is at an angle of 35°16′.

Isometric Projection

Isometric means "equal measure." In an ***isometric projection,*** the three principal faces of a rectangular object are equally inclined to the plane of projection. The three axes also make equal angles (120°) with each other. Refer to **Figure 11-4A**.

An isometric projection is a true orthographic projection of an object on the projection plane (where the projection lines are parallel). It may be produced by revolving the object in the multiview 45° about the vertical axis, **Figure 11-5A** and **Figure 11-5B**. This axis is represented as Line XC of the cube in **Figure 11-5B**. The object is then tilted forward until the body diagonal (Line XY) is perpendicular to the plane of projection, **Figure 11-5C**.

The vertical axis, Line XC, is at an angle of 35°16′ with the plane of projection and appears vertical on that plane. The principal axes, Lines AX and XB, appear on the plane of projection at 30° to horizontal. The three front edges, AX, XB, and XC, are called the ***isometric axes***. They are separated by equal angles of 120° in the isometric projection. Angles of 90° in the orthographic view appear as large as 120° or as small as 60° in the isometric view, depending on the viewing point.

Lines along, or parallel to, the isometric axes are called ***isometric lines***. See **Figure 11-6**. These lines are foreshortened in an isometric projection to approximately 81% of their true lengths. ***Foreshortened*** means shorter than true length.

The faces of the cube shown in **Figure 11-6** are made up of isometric lines and are called ***isometric planes***. Isometric planes include all planes parallel to the "faces." Lines that are not parallel to the isometric axes are called ***nonisometric lines***.

An isometric projection can also be obtained by means of an auxiliary projection, **Figure 11-7**. Auxiliary views are discussed in Chapter 12.

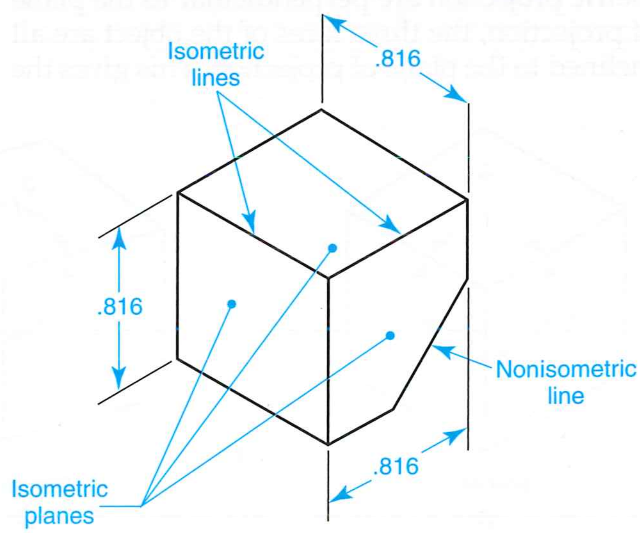


Figure 11-6. Isometric lines are parallel to the isometric axes and form surfaces called isometric planes. Lines that are not parallel to the isometric axes are called nonisometric lines. In an isometric projection, isometric lines are foreshortened to approximately 81% of their true lengths.

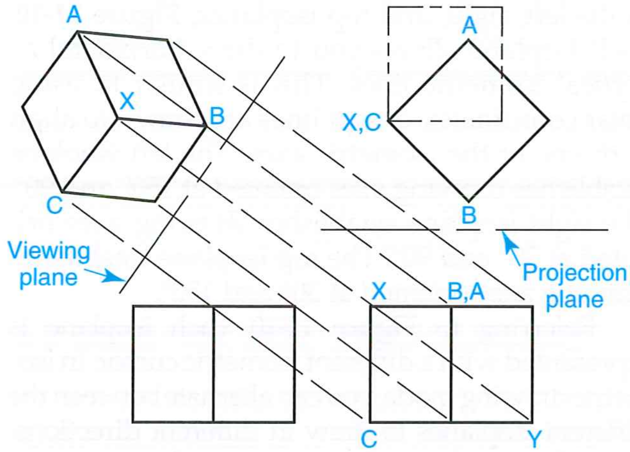


Figure 11-7. An isometric projection can be constructed by projecting an auxiliary view.

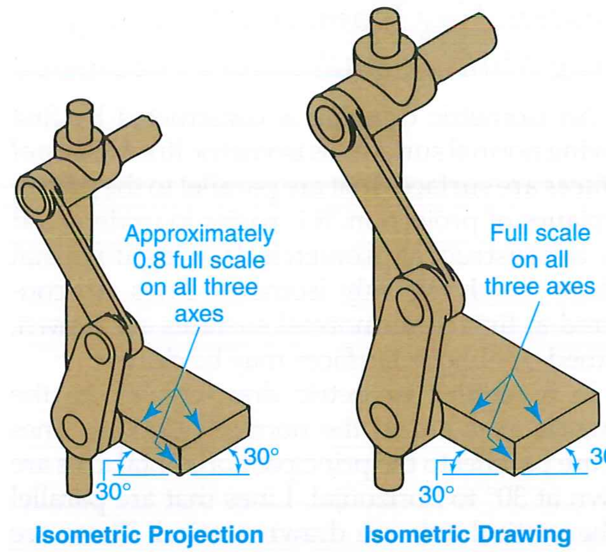


Figure 11-9. An isometric drawing of an object is similar to an isometric projection of the same object. The main difference is that the drawing is somewhat larger. (American National Standards Institute)

Isometric projections are true projections. However, for objects that are more complicated than a cube, the object must first be drawn in orthographic projection. Then the isometric projection is constructed by revolution or auxiliary projection. A special isometric scale similar to the one shown in **Figure 11-8** can also be used. However, it is more common practice to make an isometric drawing instead of an isometric projection, since direct measurements can be made on the isometric axes. This is discussed next.

Comparing isometric drawing and projection

Basically, an isometric drawing can be constructed without first laying out a multiview drawing. This simplified process is possible because measurements can be made with a regular scale on the isometric axes of the drawing.

The main difference between isometric drawing and isometric projection is that isometric drawings tend to be larger, **Figure 11-9**. Actual measurements (full length measurements) are used in an isometric drawing, while foreshortened measurements are projected in the isometric projection.

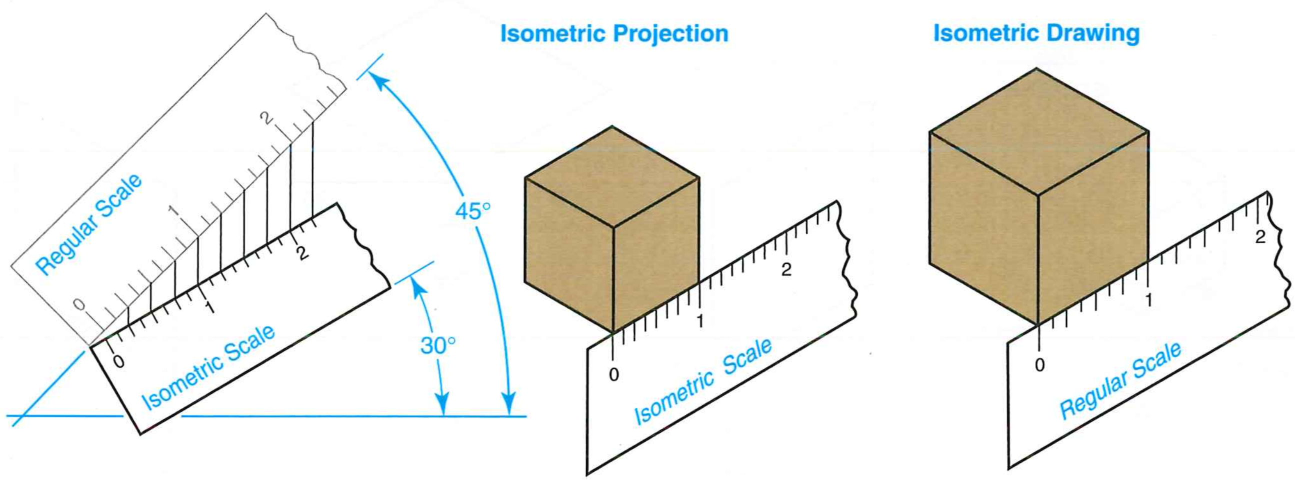


Figure 11-8. An isometric scale can be constructed for use in isometric projection. An isometric scale is a foreshortened version of a "regular" scale.

Constructing Isometric Drawings Using Manual and CAD Procedures

An isometric drawing is constructed by first drawing normal surfaces as isometric lines. ***Normal surfaces*** are surfaces that are parallel to the principal planes of projection. It is easier to understand how to construct an isometric drawing if normal surfaces involving only isometric lines are considered at first. After normal surfaces are drawn, inclined or oblique surfaces may be drawn.

In a regular isometric drawing (where the isometric axes are in the normal position), lines that are parallel to the principal horizontal axes are drawn at 30° to horizontal. Lines that are parallel to the vertical axis are drawn vertical. These are simple guidelines to remember when drawing normal surfaces in a regular isometric drawing.

The same principles are used to construct isometric drawings in both manual and CAD drafting. However, different tools and methods are used. In manual drafting, manual drawing instruments are used. These include a 30°-60° triangle, straightedge, and compass, in addition to irregular curves and isometric ellipse templates.

In CAD drafting, special tools and commands are available for creating and displaying isometric views. The most common way to create an isometric drawing is to configure the current drafting settings to use isometric snap. ***Isometric snap*** is a function that allows you to draw lines along the isometric axes. In a typical CAD program, the axes define three isometric planes called the ***isoplanes***. The three isoplanes are referred to as the left, right, and top isoplanes, **Figure 11-10**. Each isoplane allows you to draw horizontal or vertical isometric lines. This is similar to using polar coordinates, except lines are drawn to align with one of the isometric axes. The left isoplane establishes drawing axes oriented at 150° and 90°. The right isoplane establishes drawing axes oriented at 30° and 90°. The top isoplane establishes drawing axes oriented at 30° and 150°.

Referring to **Figure 11-10**, each isoplane is represented with a different isometric cursor. In isometric drawing mode, you can alternate between the different isoplanes to draw in different directions. Typically, you do not have to exit a drawing command to activate a different isoplane. For example, you may need to change the drawing direction several times when using the **Line** command. Each time a new orientation is selected, the isometric cursor changes to indicate the drawing direction.

In isometric drawing mode, it is often helpful to use Ortho mode in conjunction with direct distance entry. This allows you to quickly enter width, depth, or height distances when drawing isometric lines. Isometric grid is also commonly used with isometric snap. The ***isometric grid*** function sets the drawing grid to an isometric pattern of dots. This provides a visual aid to indicate the direction of the isometric axes.

Creating 2D drawings in isometric drawing mode is one way to draw CAD-based isometric views. Another way to create isometric views is to draw three-dimensional (3D) models and display them at different isometric viewing angles. CAD programs typically allow you to orient

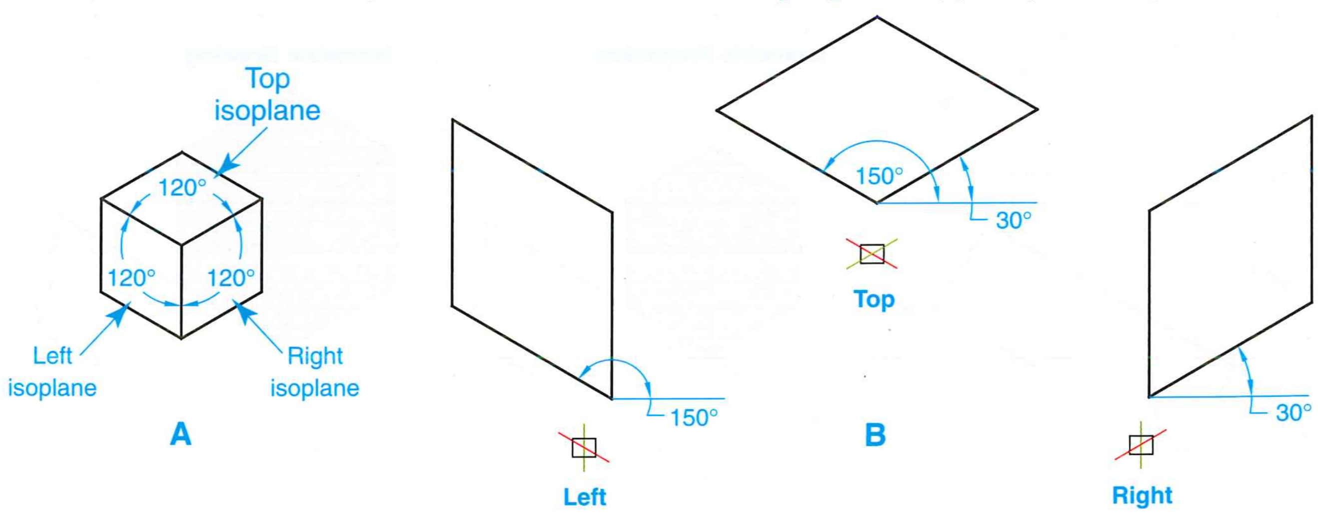


Figure 11-10. Isometric snap simplifies the task of drawing isometric views in CAD drafting. A—The left, right, and top isoplanes are defined by the isometric axes. B—The isoplanes establish different orientations for drawing isometric lines. An isometric cursor identifies the current isoplane setting.

drawings to one of several preset isometric views. This is a quick way to display different views of a model. Similar types of viewing tools are used for creating perspective views of models. This is discussed later in this chapter.

Manual and CAD procedures for constructing isometric views are discussed in the following sections. If you are drawing manually, block in each view with light construction lines and darken the lines to complete the drawing. If you are using CAD methods, remember to select the most appropriate tools and commands available to you to make the best use of drawing time.

Construct an Isometric Drawing with Normal Surfaces

Using Instruments (Manual Procedure)

The object shown in **Figure 11-11** is made up of normal surfaces. It is constructed as follows.

1. Draw an isometric block equal to the width, depth, and height of the object shown in the multiview drawing, **Figure 11-11A**. The isometric lines representing the width and depth are drawn at 30°. The isometric lines representing the height are drawn vertical.
2. Lay off dimensions along the isometric lines for the cut through the top. Draw isometric lines to complete the feature, **Figure 11-11B**.
3. Erase unnecessary construction lines and darken the pictorial, **Figure 11-11C**.

Note

Hidden lines are omitted from isometric drawings unless needed for clarity.

Using Isometric Snap (CAD Procedure)

1. The dimensions of the object are given. Refer to the multiview drawing in **Figure 11-11**.
2. Access the drafting settings and make isometric snap active. Enter the **Line** command. Using Ortho mode and direct distance entry, draw the baselines of the object using the width and depth dimensions shown in the multiview drawing. Use the left and right isoplane settings. Then, draw the three vertical lines extending to the top of the object using the height dimension. Use object snaps as needed. Refer to **Figure 11-11A**.
3. Draw horizontal isometric lines from the top corners of the object extending to the cut surface. Then, draw vertical and horizontal isometric lines to create the cut using the dimensions shown in the multiview drawing. Change the current isoplane setting and use object snaps as needed. Refer to **Figure 11-11B**.
4. Draw the remaining isometric lines using object snaps.

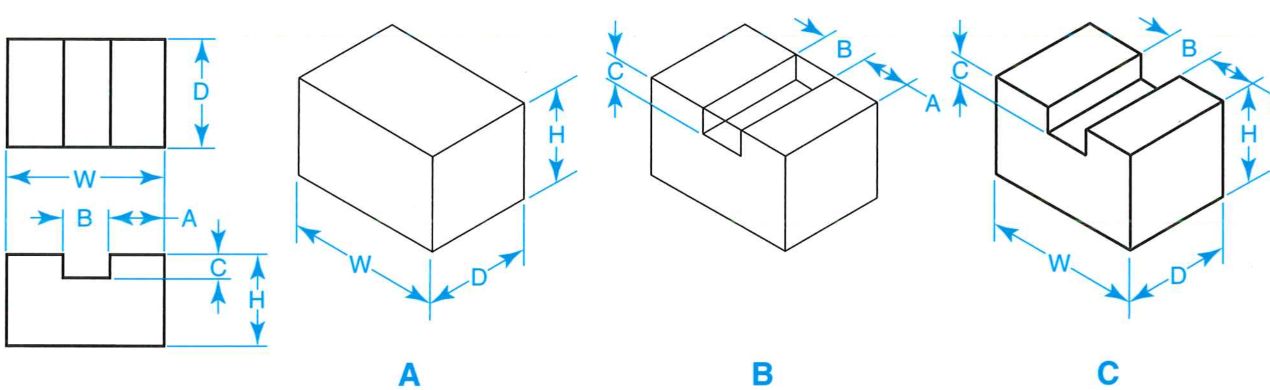


Figure 11-11. Constructing an isometric view of an object with normal surfaces. A—Isometric constructions are easier if an isometric "block" is first drawn using the total outside dimensions. B—The details of the object are added. C—All construction lines are removed and the object lines darkened.

Construct an Isometric Drawing with Nonisometric Lines

Using Instruments (Manual Procedure)

Inclined or oblique surfaces on isometric drawings are drawn as nonisometric lines. Nonisometric lines cannot be measured directly on the drawing. These lines are drawn by locating the endpoints on isometric lines and then drawing the lines. All measurements on isometric drawings must be made parallel to the isometric axes. Nonisometric lines are not shown as true length.

The object shown in **Figure 11-12** includes inclined surfaces. It is constructed as follows.

1. Draw an isometric block equal to the width, depth, and height of the object shown in the multiview drawing, **Figure 11-12A**.
2. Lay off, along isometric lines, the endpoints of the nonisometric lines, **Figure 11-12B**.
3. Use a straightedge to join the endpoints, **Figure 11-12C**.
4. Erase unnecessary construction lines and darken the pictorial.

Using Isometric Snap and Editing Commands (CAD Procedure)

1. The dimensions of the object are given. Refer to the multiview drawing in **Figure 11-12**.
2. Access the drafting settings and make isometric snap active. Enter the **Line** command. Using Ortho mode and direct distance entry, draw horizontal isometric lines for the baselines of the object. Use the width and depth measurements shown in the multiview drawing. Change the current isoplane setting as needed.
3. Enter the **Line** command and draw the two vertical isometric lines at the front of the object. Determine the height measurement from the multiview drawing. Then, draw a horizontal isometric line between the top endpoints of the two vertical lines. Refer to **Figure 11-12C**.

4. To create the horizontal isometric line on the top surface (equal to the depth of the object), enter the **Copy** command. Copy the horizontal isometric line drawn in Step 3 to the top surface at a distance equal to Dimension B in the multiview drawing. Make the right isoplane setting current to copy the line. Then, make the top isoplane setting current and enter the **Move** command. Move the line along the top surface at a distance equal to Dimension A in the multiview drawing.
5. Enter the **Line** command and draw the three remaining isometric lines on the top surface. The two width lines should extend from the horizontal isometric line. Determine the width dimensions from the multiview drawing and use the Endpoint object snap to draw the lines. Then, draw the depth line at the rear of the object. This line should extend from the endpoint of the longer width line. Determine the length of the depth line from the multiview drawing.
6. Enter the **Line** command and draw the nonisometric lines. First, draw the two nonisometric lines near the front of the object by connecting the endpoints of the isometric lines. Then, enter the **Line** command and draw the nonisometric lines forming the inclined surface at the rear of the object. Use the Endpoint object snap to draw the three lines between the endpoints of the isometric lines. This completes the view.

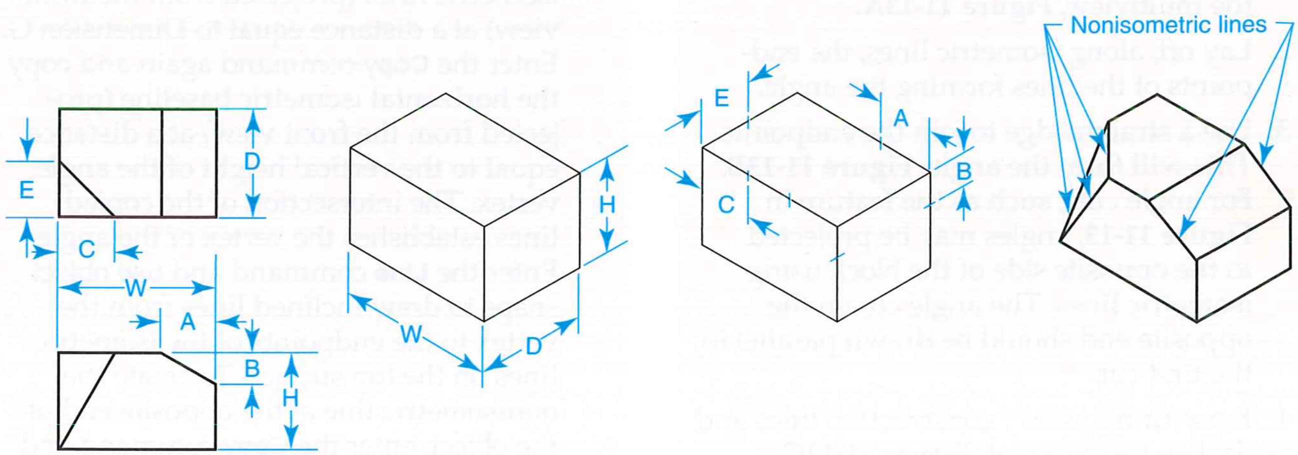


Figure 11-12. Constructing an isometric view of an object with nonisometric lines. Nonisometric lines and surfaces are not parallel to the projection plane. A—As with constructing normal surfaces, first construct an isometric "block" using the total outside dimensions. B—Locate the endpoints of the nonisometric lines on the normal isometric lines. C—Draw lines to connect the endpoints and create the nonisometric surfaces.

Construct Angles in an Isometric Drawing

Using Instruments (Manual Procedure)

Angles do not appear as true size in isometric drawings. Therefore, angles cannot be drawn to their true measure in degrees in an isometric drawing. An angle is drawn by locating the endpoints of the sides. The endpoints are then connected to form the required angle.

Use the following procedure to construct an angled feature in an isometric drawing. Refer to **Figure 11-13**.

1. Draw an isometric block equal to the width, height, and depth of the object in the multiview, **Figure 11-13A**.
2. Lay off, along isometric lines, the endpoints of the lines forming the angle.
3. Use a straightedge to join the endpoints. This will form the angle, **Figure 11-13B**. For angle cuts, such as the feature in **Figure 11-13**, angles may be projected to the opposite side of the block using isometric lines. The angle cut on the opposite end should be drawn parallel to the first cut.
4. Erase unnecessary construction lines and darken the pictorial, **Figure 11-13C**.

Using Isometric Snap and the Copy Command (CAD Procedure)

1. The dimensions of the object are given. Refer to the multiview drawing in **Figure 11-13**.
2. Access the drafting settings and make isometric snap active. Enter the **Line** command. Using Ortho mode and direct distance entry, draw the horizontal and vertical isometric lines making up the object. Start from one of the lower corners and use the width, height, and depth measurements shown in the multiview drawing. Change the current isoplane setting as needed. Refer to **Figure 11-13B**.
3. To create the 90° angle cut, enter the **Copy** command. Make the right isoplane setting current and copy one of the vertical isometric lines (projected from the front view) at a distance equal to Dimension G. Enter the **Copy** command again and copy the horizontal isometric baseline (projected from the front view) at a distance equal to the vertical height of the angle vertex. The intersection of the copied lines establishes the vertex of the angle. Enter the **Line** command and use object snaps to draw inclined lines from the vertex to the endpoints of the isometric lines on the top surface. To create the nonisometric line at the opposite end of the object, enter the **Copy** command and

copy the inclined line lying parallel to the required line (the inclined line drawn in the same direction). Use object snaps. Erase the unneeded copied lines when finished.

4. To create the 60° angle cut, enter the **Copy** command. Make the top isoplane setting current. Copy the horizontal isometric line extending along the right isoplane from the intersection of the right and left isoplanes on the top surface. Copy this line at a distance equal to Dimension D. Enter the **Copy** command again. Copy the horizontal isometric line adjacent to the angle vertex extending the width of the object on the top surface. Copy this line at the required distance to the angle vertex along the top surface. The intersection of the copied lines establishes the vertex of the angle. Enter the **Line** command and use object snaps to draw inclined lines from the vertex to the endpoints of the isometric lines on the top surface. To create the nonisometric line at the opposite end (bottom) of the object, enter the **Copy** command and copy the inclined line lying parallel to the required line (the inclined line drawn in the same direction). Erase the unneeded copied lines when finished. This completes the view.

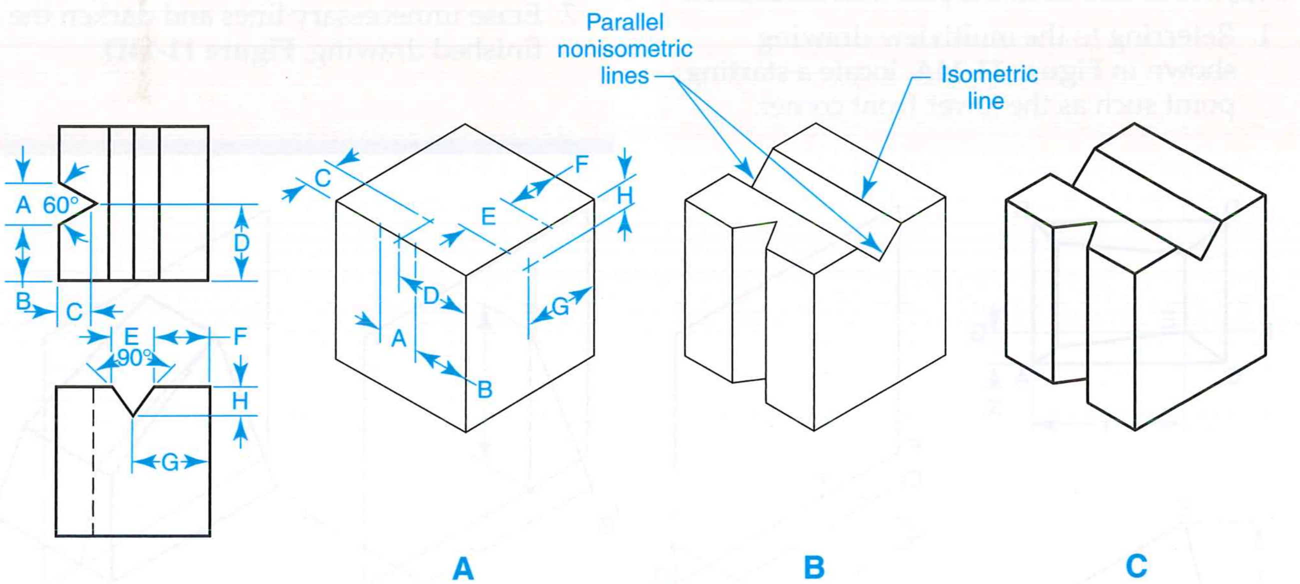


Figure 11-13. Constructing angled features in isometric drawings. A—First construct an isometric "block" using the total outside dimensions. B—Locate the endpoints of the angle by measuring on or parallel to isometric lines. C—Draw lines to connect the endpoints and form the angle.

CAD Lay Out an Isometric Drawing Using the Coordinate Method

When laying out isometric views manually, the "block" method is useful for objects that are cubic in shape. However, for objects that have fewer normal surfaces and more inclined features, the coordinate method may be more suitable, **Figure 11-14**. This method is used to offset measurements. The truncated pyramid shown can be drawn manually using the coordinate method. If you are using a CAD system, you can use isometric snap and the **Copy** command as in the previous discussion.

1. Referring to the multiview drawing shown in **Figure 11-14A**, locate a starting point such as the lower front corner. Draw two horizontal axes, **Figure 11-14B**. These axes will be inclined upward at 30°. *Note:* Centering an isometric drawing in a layout is covered later in this chapter.
2. Lay off the lengths of the two base edges.
3. Construct Baseline FG of the assumed isometric plane passing through Point E by measuring the offset of Distance X.
4. Locate Distance Y from Corner A of the pyramid and project a line to intersect Line FG at Point Y′.
5. Construct a vertical line at Point Y′ and lay off the height of Point E, **Figure 11-14C**. Then, draw Line EC.
6. Continue to locate the remaining points of the truncated cut in a similar manner.
7. Erase unnecessary lines and darken the finished drawing, **Figure 11-14D**.

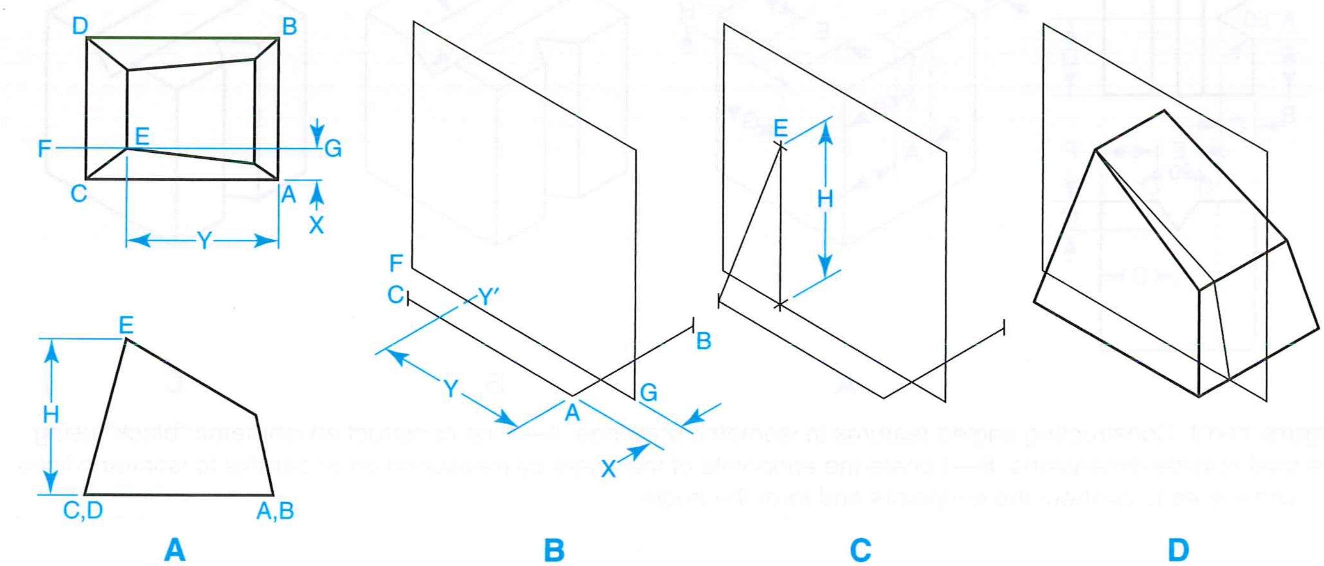


Figure 11-14. Using the coordinate method to construct an isometric drawing.

Constructing isometric circles and arcs

Circles and arcs appear as ellipses or partial ellipses in isometric drawings. One method used to construct isometric ellipses in manual drafting is the four-center approximate method. This method approximates a true ellipse, **Figure 11-15A**. True ellipses can also be drawn with an isometric ellipse template, **Figure 11-15B**. The coordinate method, also discussed in this chapter, can also be used. In CAD drafting, isometric ellipses are drawn using the **Ellipse** command. These methods are discussed in the following sections.

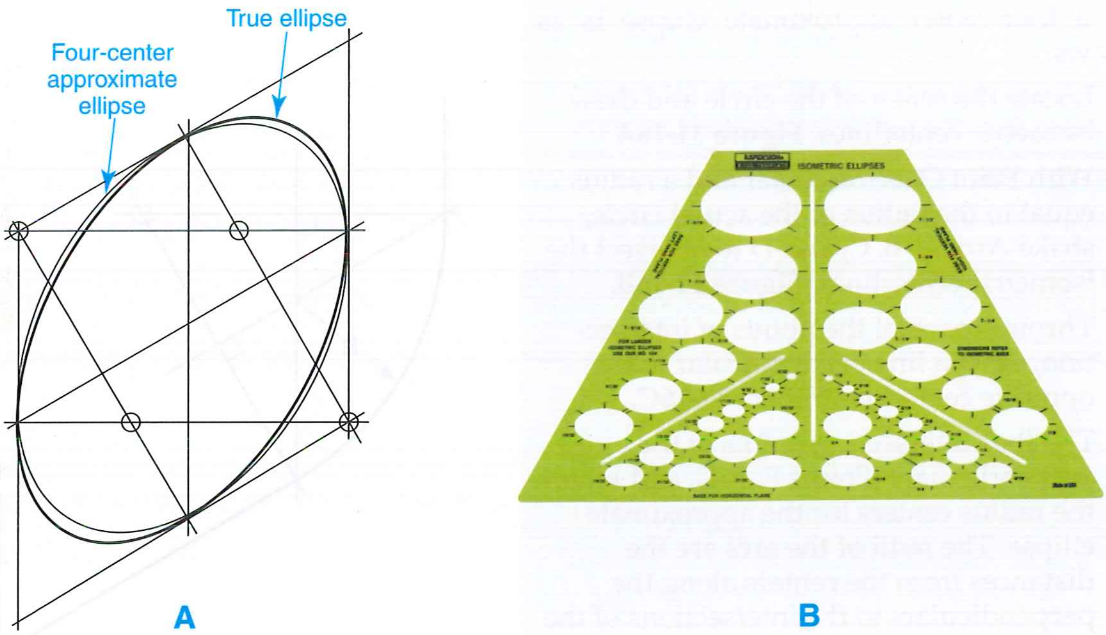


Figure 11-15. Circles and arcs are drawn as ellipses in isometric views. A—A four-center approximate ellipse is a close approximation of a true ellipse. B—Isometric ellipse templates make drawing ellipses quick and easy. (Alvin & Co.)

Draw Isometric Circles and Arcs Using the Four-Center Approximate Method

The four-center approximate method is fast and effective for most isometric drawings. If tangent circles are involved, the process is not quite as simple. The procedure for drawing a four-center approximate ellipse is as follows.

1. Locate the center of the circle and draw isometric centerlines, **Figure 11-16A**.
2. With Point O as the center and a radius equal to the radius of the actual circle, strike Arcs A, B, C, and D to intersect the isometric centerlines, **Figure 11-16B**.
3. Through each of the points of intersection, draw a line perpendicular to the opposite centerline, **Figure 11-16C**.
4. The four intersecting points of the perpendiculars (Points E, F, G, and H) are the radius centers for the approximate ellipse. The radii of the arcs are the distances from the centers along the perpendiculars to the intersections of the isometric centerlines. In **Figure 11-16**, the radii are EA, FB, GD, and HA (as shown in **Figure 11-16C**).
5. Draw Arcs CA, BD, AB, and CD to complete the ellipse, **Figure 11-16D**.

An isometric arc is constructed using the four-center approximate method by determining the required portion and drawing that segment, **Figure 11-17**.

The construction of isometric circles using the four-center approximate method is shown in each of the three principal isometric planes in **Figure 11-18**. The same procedure is used in each case in drawing isometric ellipses by this method, regardless of position.

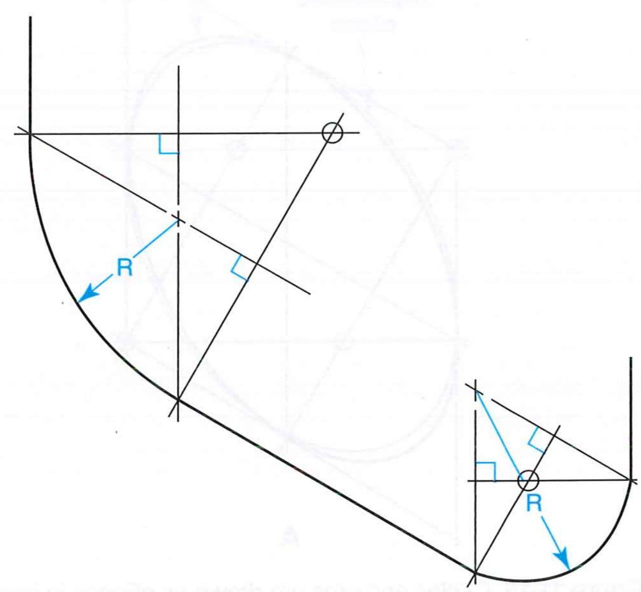


Figure 11-17. Isometric arcs can be constructed by using the four-center approximate method of constructing an ellipse. Instead of drawing the entire ellipse, select the vertex that will produce an approximation of the required arc.

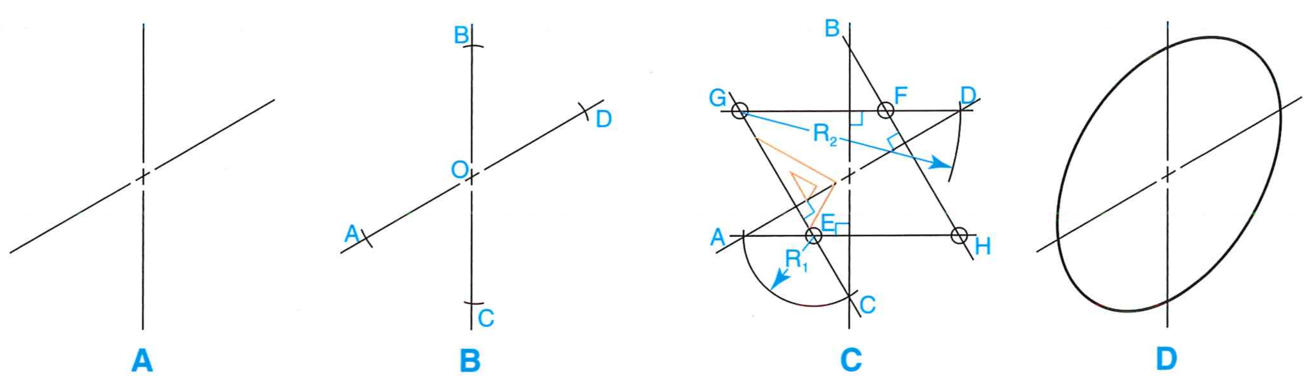


Figure 11-16. The four-center approximate method of constructing an isometric ellipse is a quick and effective method to use.

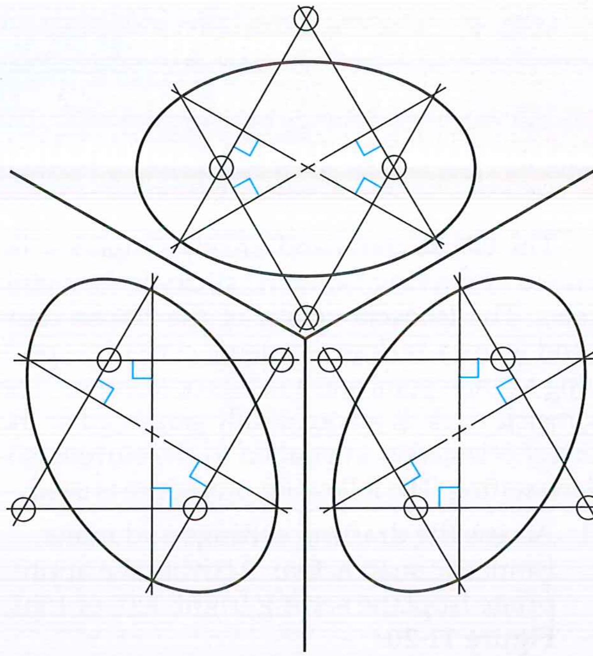


Figure 11-18. The four-center approximate method can be used in all three principal isometric planes.

Draw Isometric Circles and Arcs Using the Coordinate Method

The coordinate method of drawing an isometric circle is a process of plotting coordinate points on a true circle. These points are then transferred to an isometric square that is the same size as the circle to be drawn, **Figure 11-19**. This method results in a true projection of the isometric ellipse.

1. Locate the center of the isometric circle and draw centerlines, **Figure 11-19A**.
2. Strike arcs equal to the radius of the required circle. Construct an isometric square, **Figure 11-19B**.
3. Draw a semicircle adjacent to one side of the isometric square.
4. Divide the semicircle into an even number of equal parts. Project these divisions to a side of the square.
5. From the intersection points, draw lines across the isometric square parallel to the centerline.
6. Transfer Points 1, 2, 3, and 4 from the semicircle to the upper left quarter of the isometric square by setting off the appropriate distances, **Figure 11-19C**. Repeat this for the upper right quarter of the square. Project these intersections to the two lower quarters of the square.
7. Draw a smooth curve through these points to form an isometric ellipse, **Figure 11-19D**.

Arcs are constructed by the coordinate method in the same manner as circles. The required arc is divided into a number of equal parts and these points are projected to the isometric view. A smooth arc is then drawn through the projected coordinate points.

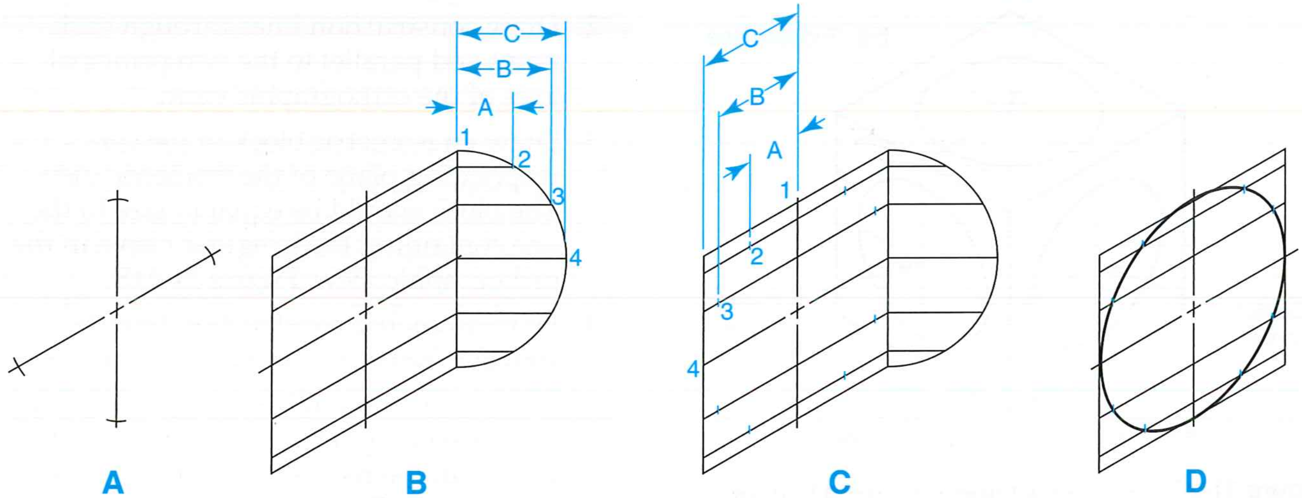


Figure 11-19. Using the coordinate method to construct an isometric circle.

Draw Isometric Circles and Arcs Using the Ellipse Command

The **Ellipse** command greatly simplifies the process of creating isometric circles in isometric views. The **Isocircle** option of the **Ellipse** command is used to draw isometric circles by specifying a center point and a radius or diameter. The isometric circle is automatically generated in the correct orientation in relation to the current isoplane setting. The following procedure is used.

1. Access the drafting settings and make isometric snap active. Activate the appropriate isoplane setting (right, left, or top), **Figure 11-20**.
2. Enter the **Ellipse** command. Enter the **Isocircle** option. Pick a center point and then drag the cursor to specify the radius. You can also enter a radius or diameter value. This completes the required isometric circle.

The **Arc** and **Isocircle** options of the **Ellipse** command allow you to draw isometric arcs (portions of isometric ellipses). You must specify a center point, a radius or diameter, and start and end angles. The start and end angles define the starting and ending points of the arc segment.

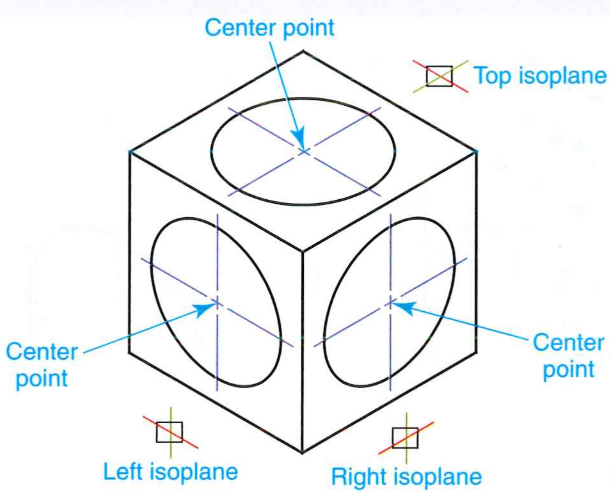


Figure 11-20. Using the **Ellipse** command to draw isometric circles.

Constructing irregular curves in isometric drawings

Irregular curves can be constructed in isometric views manually by using the coordinate method. In this method, points are plotted in an isometric view and connected with a smooth curve. In CAD drafting, points may be transferred from a multiview drawing to an isometric view to establish the locations of isometric lines. Then, coordinates can be plotted for the curve by using the **Copy** command to copy construction lines using dimensions from the multiview. The curve can then be drawn by using the **Spline** command to connect the plotted points. However, it may be more suitable to create the drawing as a 3D model and display an isometric view. This is discussed in more detail later in this chapter.

Draw Irregular Curves in Isometric Drawings

Using the Coordinate Method (Manual Procedure)

1. Select a sufficient number of points on the irregular curve in the multiview drawing to produce an accurate representation when transferred to the isometric view, **Figure 11-21A**. (Be sure to locate a point at each sharp break or turn.)
2. Draw construction lines through each point and parallel to the two principal axes of the orthographic view.
3. Draw an isometric block in the corresponding plane of the isometric view. The block should be equal in size to the one containing the irregular curve in the orthographic view, **Figure 11-21B**.
4. Draw isometric construction lines to transfer the coordinates in the multiview.
5. Draw a smooth curve through the points of intersection in the isometric view. This will form the required irregular curve, **Figure 11-21C**.

6. Project coordinate points to form the thickness of the object (if there is a thickness). Refer to **Figure 11-21C**.

Using the Copy and Spline Commands (CAD Procedure)

1. The multiview drawing is given. Refer to **Figure 11-21A**.
2. Using the **Xline** command, draw construction lines to define coordinate points along the curve. Draw enough construction lines to produce an accurate representation when the points are transferred to the isometric view.
3. Access the drafting settings and make isometric snap active. Enter the **Line** command. Using Ortho mode and direct distance entry, draw the horizontal and vertical isometric lines making up the outline of the object in the isometric view. Refer to **Figure 11-21B**.
4. Enter the **Copy** command. Using the coordinate distances established on the curve in the multiview drawing, copy the isometric lines to establish intersection points in the isometric view.
5. Enter the **Spline** command. Draw a curve through the intersection points in the isometric view.
6. Enter the **Copy** command. Copy the curve to establish the thickness of the object. Use the width dimension from the multiview drawing and change the current isoplane setting as needed. To complete the object, enter the **Line** command and draw the isometric lines establishing the thickness.

It may be easier to create the object in **Figure 11-21** as a 3D model using the **Extrude** command. This can be done by extruding the front view of the multiview drawing to the given width dimension. Then, use the **View** command to display an isometric view of the model. Creating 3D views of models is discussed later in this chapter.

Constructing isometric section views

Isometric section views are an effective means of graphically describing the interior of complex machine parts or assemblies. Full sections and half sections are frequently used in isometric drawings. An isometric full section should be drawn so that one of the isometric axes is on the cutting plane, **Figure 11-22A**. When an isometric half section is used, the correct way to draw the view is to position the part where both sides of the removed section are visible, **Figure 11-22B**. The cutting planes should be parallel to the isometric axes. Occasionally, a broken-out section is useful in showing a particular feature in an isometric view, **Figure 11-23**.

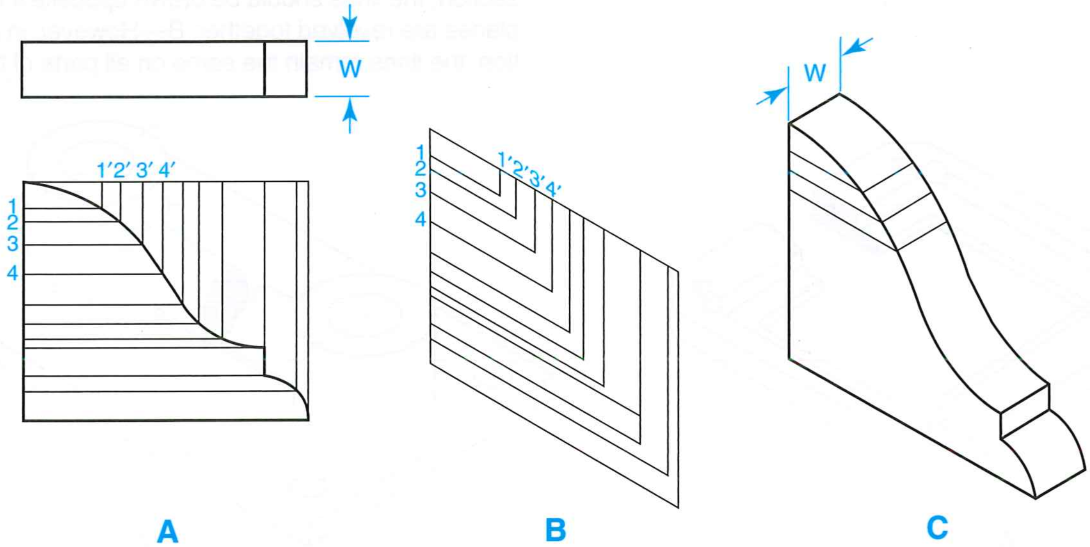


Figure 11-21. Using the coordinate method to transfer an irregular curve to an isometric drawing.

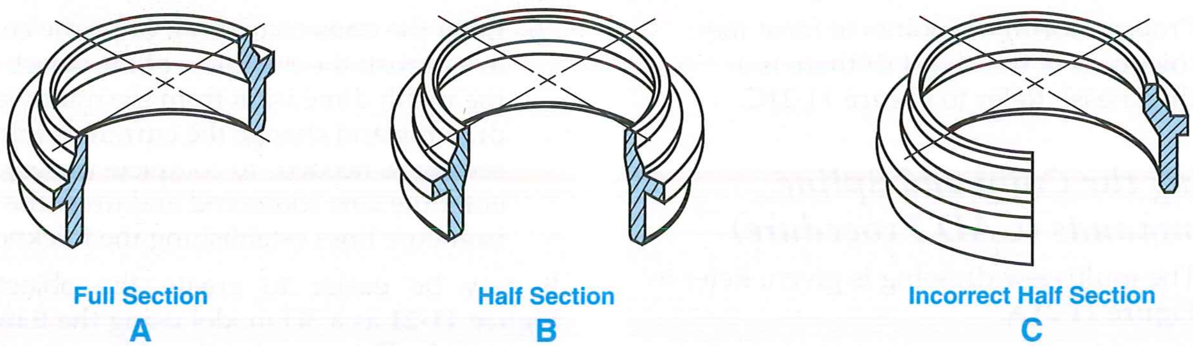


Figure 11-22. Isometric section views. A—For full section views, the cutting plane should be parallel to one of the isometric axes. B—The cutting planes for isometric half section views should be parallel to the isometric axes. C—The cutting planes for isometric half section views should *not* be parallel to the edges of the drawing sheet.

Section lines are normally drawn at an angle of 60°, **Figure 11-24A**. This angle closely resembles the 45° crosshatching in multiviews. If a 60° angle will cause the section lining to be parallel or perpendicular to the visible outline of the object, a different angle should be chosen, **Figure 11-24B**. In addition, certain conventions should be followed for orienting section lining in the proper direction. In an isometric full section, the direction of lines remains the same on all portions "cut" by the cutting plane. An exception to this is if the view is of an assembly with several parts. Section lines in an isometric half section should be drawn in opposite directions if the two planes of the section were revolved together. Refer to **Figure 11-24A**.

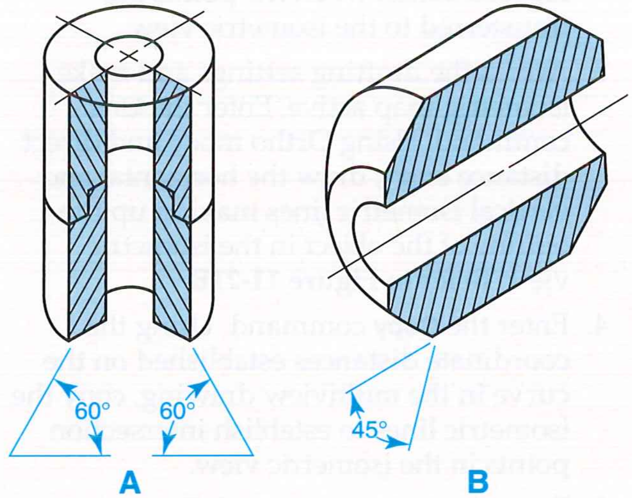


Figure 11-24. Section lines in isometric views are normally drawn at 60°. However, another angle should be chosen if 60° will produce lines that are parallel, or close to parallel, to the object lines. A—In an isometric half section, the lines should be drawn opposite if the cutting planes are revolved together. B—However, in a full section, the lines remain the same on all parts of the object.

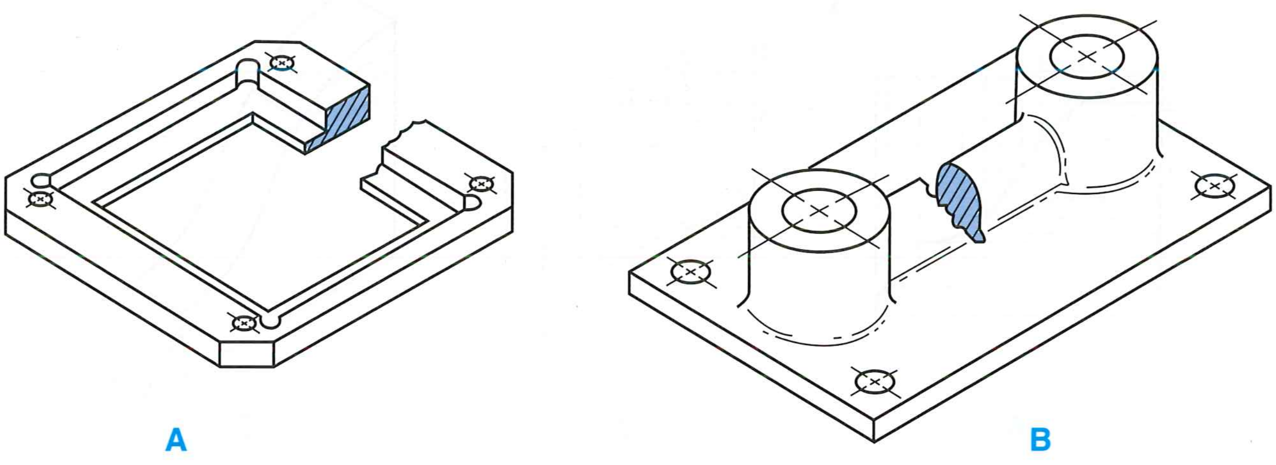


Figure 11-23. Broken-out sections can be useful to show a particular detail in an isometric view.

Draw an Isometric Section View

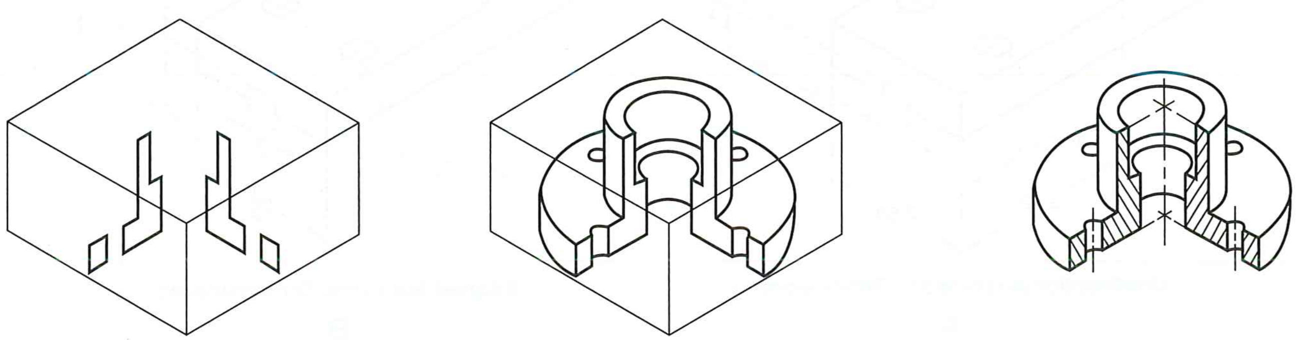
Using Instruments (Manual Procedure)

1. Draw an isometric block equal to the width, depth, and height of the object. The lines should be drawn very light, **Figure 11-25A**.
2. Draw the outline of the object along the cutting plane. Refer to **Figure 11-25A**.
3. Add the remaining details, **Figure 11-25B**.
4. Erase the construction lines and add the crosshatching, **Figure 11-25C**.

Using the Line and Hatch Commands (CAD Procedure)

1. The given object is to be drawn in a half isometric section view. Refer to **Figure 11-25**.
2. Access the drafting settings and make isometric snap active. Enter the **Line** command. Using Ortho mode and direct distance entry, draw the horizontal and vertical isometric lines making up the outline of the object along the cutting plane in the isometric view. Change the current isoplane setting as needed.
3. Enter the **Ellipse** command. Draw the isometric circles and arcs making up the rounded features of the section view. Refer to **Figure 11-25B**. Draw construction lines or use the **Copy** command to "offset" lines to locate the center of each feature.
4. Enter the **Hatch** command. Add hatch lines to the "cut" surfaces using the appropriate hatch pattern. Change the angular value of the pattern to match the desired angle shown in **Figure 11-25**.

Another way to create an isometric section view is to draw a 3D model and then section it using the **Section Plane** command. This command allows you to draw a cutting plane and orient it as desired to show the interior features. The plane can be "offset" to show different types of sections (including half sections and offset sections). Use the **View** command to establish the desired isometric view of the model, and then enter the **Section Plane** command to draw the cutting plane. The command provides options for adding a hatch pattern to the cut surfaces and changing the hatch angle.



A B C

Figure 11-25. Constructing an isometric section view. A—First draw an isometric block and locate the sectioned faces inside. B—Draw the remaining parts of the object. C—Darken the object lines, add the section lines, and remove the construction lines.

Isometric dimensioning

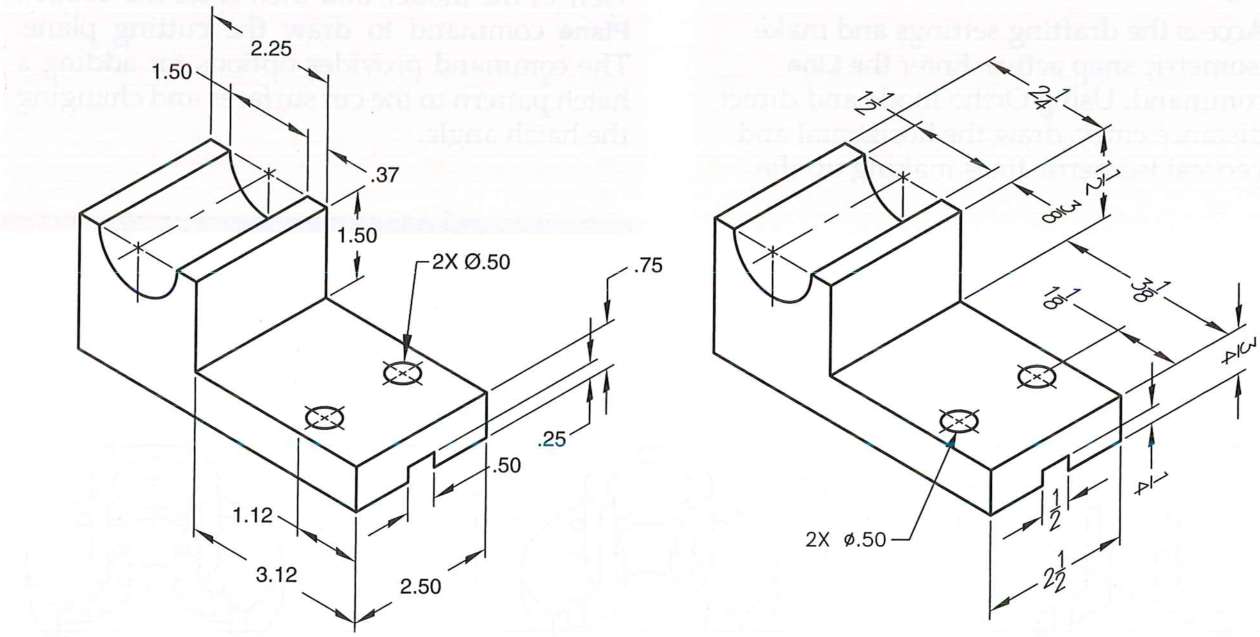
The general rules for dimensioning multiview drawings also apply to isometric drawings. The unidirectional dimensioning system is the preferred practice, **Figure 11-26A**. In this system, the dimension lines and extension lines lie in the correct plane for the feature dimensioned. For convenience and speed in drawing, the dimension figures and notes are shown in one plane (they are placed parallel to the picture plane). This permits them to be easily read from the bottom of the drawing. However, the dimension and extension lines must be properly aligned.

The aligned or isometric plane dimensioning system is also in practice, **Figure 11-26B**. In this system, the dimension lines, extension lines, dimension figures, and notes lie in the principal isometric planes. This type of dimensioning is used on older drawings and is more time-consuming than unidirectional dimensioning. Correct and incorrect practices used in isometric dimensioning are shown in **Figure 11-27**.

Representing screw threads in isometric views

In manual drafting, a great amount of time is required to draw the actual representation of screw threads in isometric drawings. The increase in clarity of the drawing is not large enough to justify the time required. As a result, actual representation is seldom used. The practice is to represent crest lines of threads with a series of uniformly spaced isometric circles (ellipses), **Figure 11-28A**. It is not necessary to duplicate the actual pitch of the thread. The dimension will identify thread characteristics. Shading may be used to increase effectiveness of the thread representation, **Figure 11-28B**.

In CAD drafting, some programs provide special 3D drawing commands to create screw threads. In 2D-based CAD drafting, threads can be drawn by using the **Ellipse** command to create isometric circles and arcs.



Unidirectional Isometric Dimensioning
A

Aligned Isometric Dimensioning
B

Figure 11-26. Unidirectional and aligned isometric dimensioning. In both systems, the dimension lines and extension lines are placed in the plane corresponding to the feature being dimensioned. A—In unidirectional dimensioning, dimension figures and notes are placed in one plane. B—In aligned dimensioning, dimension figures and notes are placed in the principal isometric planes with the other dimensioning elements.

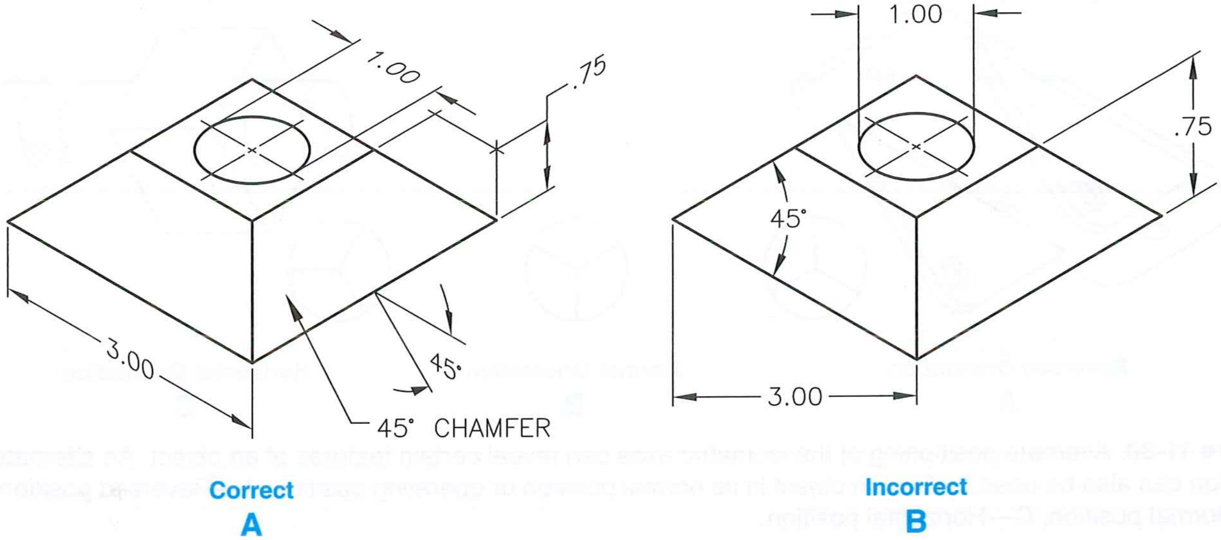


Figure 11-27. Isometric dimensions should be placed in the plane corresponding to the feature being dimensioned. A—If necessary, add additional extension lines to locate a dimension. B—Incorrect practices.

Isometric ellipse templates

In manual drafting, the four-center approximate and coordinate methods of constructing isometric circles can be very time-consuming. When isometric ellipse templates are available in the correct size, they should be used to speed the process of drafting. The appearance of the finished drawing is also greatly improved by using templates. Isometric ellipse templates are available in a variety of sizes. Their use simply requires alignment of the template along the isometric centerlines of the circular feature. In some cases, vertical and horizontal centerlines can be used for drawing alignment with an ellipse template, **Figure 11-29**.

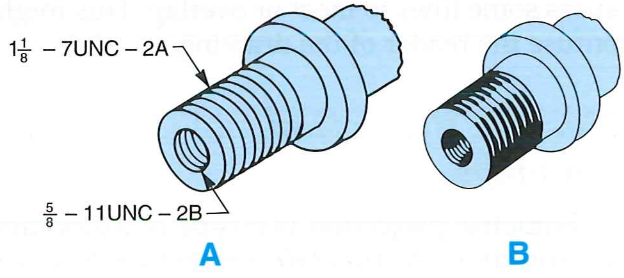


Figure 11-28. Screw threads are represented in isometric views by uniformly spaced isometric circles. A—The circles represent the crest of the thread. B—Shading can be added to better represent the threads. (American National Standards Institute)

Alternate positions of isometric axes

As discussed earlier in this chapter, in a regular isometric drawing, the isometric axes are in the normal position. However, it may be desirable to draw an object in isometric with the axes in a position other than the normal position. For example, the object can be viewed from below by placing the axes in a reversed position, **Figure 11-30A**. Long objects can be shown horizontally by placing the axes in a horizontal position, **Figure 11-30C**. The isometric axes may be located in any number of positions as long as equal 120° angles are maintained between the three axes.

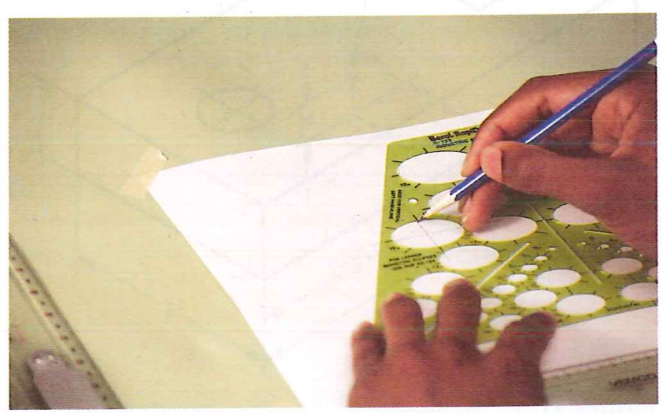


Figure 11-29. Isometric ellipse templates are aligned using the isometric centerlines as guides. Regular horizontal and vertical centerlines can also be used in some cases.

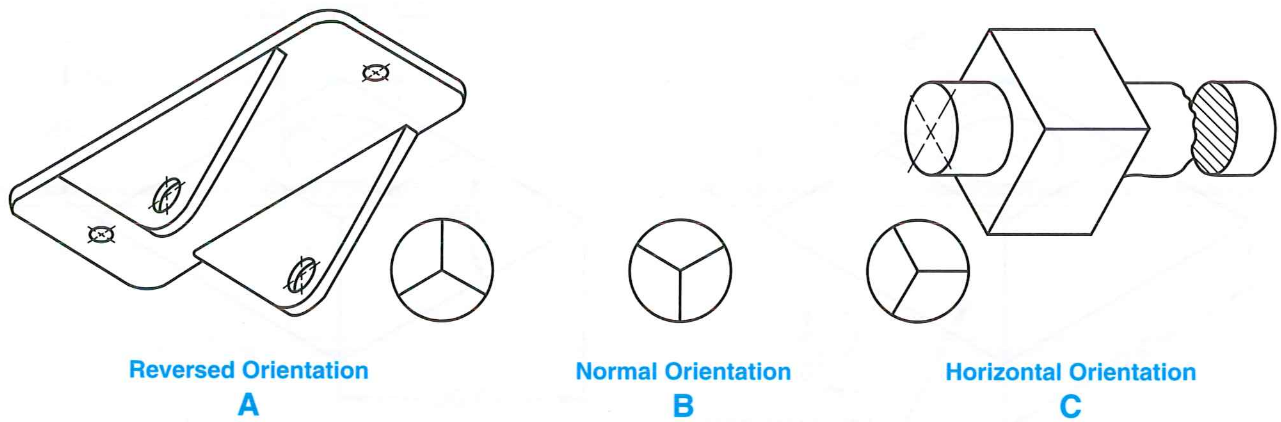


Figure 11-30. Alternate positioning of the isometric axes can reveal certain features of an object. An alternate position can also be used to view an object in its normal position or operating position. A—Reversed position. B—Normal position. C—Horizontal position.

Centering an isometric drawing

To locate an isometric drawing in the center of a sheet, or at any other location, determine the center of the object and position it in the desired location, **Figure 11-31**. Match this center point with the desired center location on the sheet. The "starting point" should be located from this point by measuring parallel to the isometric axes. The entire isometric drawing will then be correctly positioned.

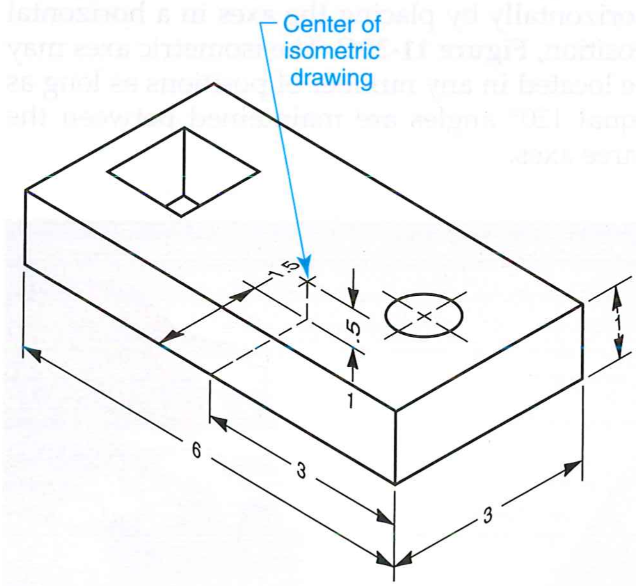


Figure 11-31. To center an isometric drawing, first locate the center of the object. Then place this point in the center of the sheet or work space. This method can also be used to locate an isometric view at any desired location on the sheet.

Advantages and disadvantages of isometric drawings

The isometric drawing is one of the easiest to construct since the same scale is used on all axes. It has an advantage over orthographic projection in that three sides of the object may be shown in one view. This presents a more realistic representation of the object. Circles are not greatly distorted, as in the receding views of an oblique drawing (oblique drawings are discussed later in this chapter).

There are certain disadvantages inherent in isometric drawings. One is the tendency for long objects to appear distorted. This is the case because parallel lines on an object remain parallel, rather than converging toward a distant point. In a perspective drawing, by comparison, the parallel lines of an object appear to converge at a point called the *vanishing point*. This is more representative of what is seen by the human eye. Also, the symmetry of an isometric drawing causes some lines to meet or overlap. This might confuse the reader of the drawing.

Dimetric Projection and Dimetric Drawings

Dimetric projection is a type of axonometric projection. A ***dimetric projection*** has two faces equally inclined to the plane of projection. (Refer to Faces 1 and 3 in **Figure 11-4B**.) Two axes make equal angles with each other. (Refer to Angles e and f in **Figure 11-4B**.) The third face and axis are inclined differently.

The two equal angles can be any angle larger than 90° and less than 180° that is not equal to 120°. (If the equal angles are 120°, the third angle must also be 120° and the drawing becomes an isometric projection.) The third axis makes an angle that is either larger or smaller than the two equal angles.

The axes are drawn at two different scales. The two axes making equal angles, or lines parallel to these axes, are foreshortened equally. The third axis and lines parallel to it are foreshortened or enlarged more, depending on how the object is viewed. Like an isometric projection, a dimetric projection can be constructed by the revolution method or by the auxiliary view method.

A dimetric projection requires the construction of a multiview drawing. Manual constructions are used to determine the angles and scales of the axes. In order to save drafting time, it is more common to make approximate dimetric drawings. When making dimetric drawings, common combinations of scales and axis angles are used for making approximate representations.

The same projection methods used in manual dimetric projection can be used in 2D CAD drawings, but it is simpler to create a dimetric drawing using approximate scales and angles for the axes. In addition, as with other types of pictorial drawing, it is more common to create the drawing as a 3D model and then generate the desired view using special viewing commands.

Constructing a dimetric projection

The only difference between dimetric and isometric projection is the angle at which the object is viewed (the line of sight). In **Figure 11-32**, a cube is revolved in two views to the required line of sight to establish the two equal angle axes. It is then projected from the orthographic view to the dimetric projection. This produces a true measure of the cube, as well as the angle of the dimetric axes.

Careful projection techniques will produce angles and lengths accurate enough for most pictorial drafting requirements. Angles and measurements requiring mathematical accuracy should be calculated by applying trigonometry.

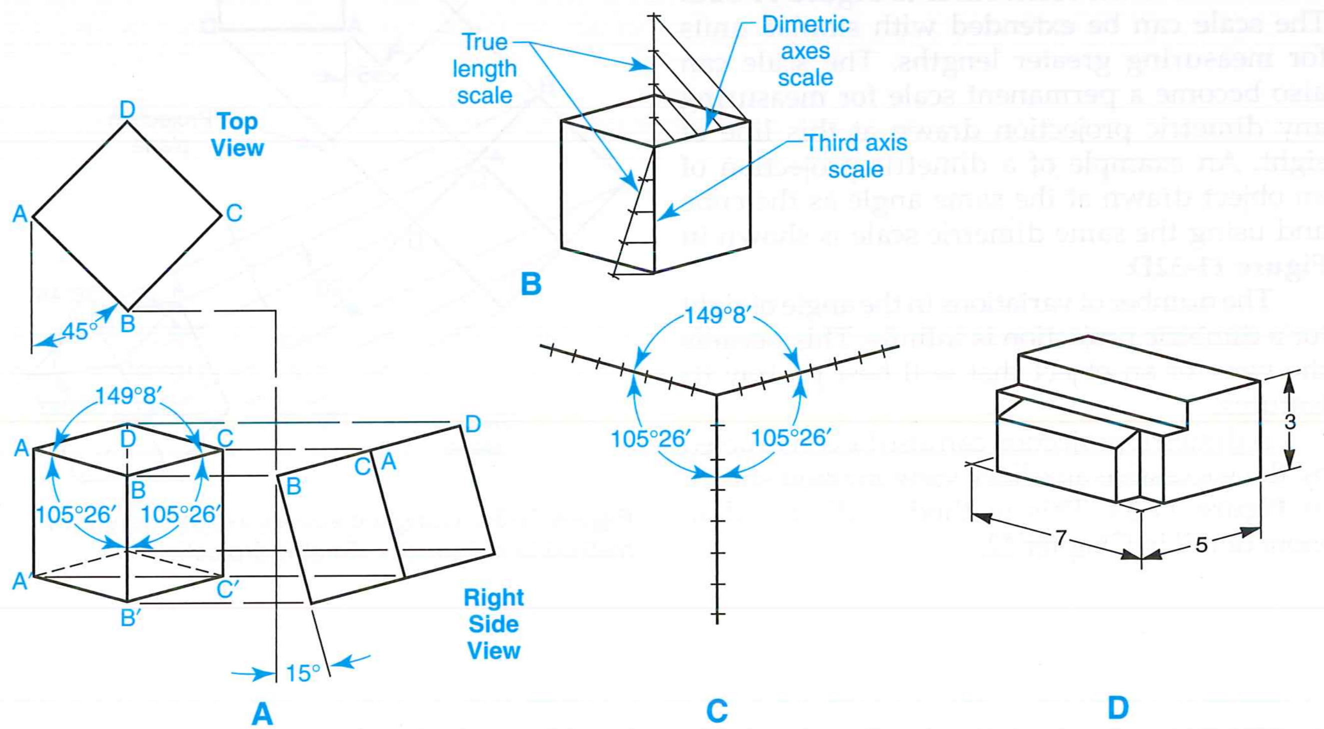


Figure 11-32. Constructing a dimetric projection. A—A projection of a cube is generated from the top and side views. B—Scale measurements are laid off as divisions on the dimetric axes and the third axis. C—The dimetric scale is constructed. D—A dimetric projection of an object drawn at the scale used for the cube.

To create a basic dimetric projection of a cube, draw two views as shown in **Figure 11-32A**. Rotate the top and side views 45°. Then, rotate the side view forward to the projection plane at an angle other than 35°16′. As shown in **Figure 11-32A**, the object is rotated forward 15°. Points are then projected from the two views to create the dimetric projection. This establishes the angles between the axes, the orientation of the dimetric axes, and the angles made by the axes with the projection plane.

Next, lay off the actual scale of the cube on a line at an angle with one of the dimetric axes and on a second line at an angle along the third axis. Refer to **Figure 11-32B**. Divide each actual measurement line into a number of equal parts. Project these divisions geometrically to divide each axis into proportionally equal parts. The two dimetric axes will be foreshortened, but will have the same measure (scale). The third axis will also be foreshortened and will have a different scale. (The third axis may appear longer or shorter than the dimetric axes, depending on the line of sight.)

To construct the dimetric scale, draw the dimetric axes and transfer the dimetric units of measure to the scale. Refer to **Figure 11-32C**. The scale can be extended with similar units for measuring greater lengths. The scale can also become a permanent scale for measuring any dimetric projection drawn at this line of sight. An example of a dimetric projection of an object drawn at the same angle as the cube and using the same dimetric scale is shown in **Figure 11-32D**.

The number of variations in the angle of sight for a dimetric projection is infinite. This permits the view of an object that will best portray its features.

A dimetric projection can also be constructed by the successive auxiliary view method shown in **Figure 11-33**. This method is discussed in more detail in Chapter 12.

Constructing an approximate dimetric drawing using manual and CAD methods

Dimetric projection drawings are commonly modified to save time. They are typically constructed as approximate dimetric drawings using regular scales and angles. A full-size scale, three-quarter scale, or half scale may be selected for the dimetric axes or the third axis, depending on which is to be reduced. In manual drafting, the axes and other features can be easily drawn to these scales using triangles or a compass.

Angles closely approximating those of a true projection can be used for drawing axis lines. In manual drafting, the angles can be easily measured with the protractor or adjustable triangle.

A regular full-size scale or a foreshortened scale can be used on the different axes depending on their positions in the dimetric view. Some common axis angles for approximate dimetric

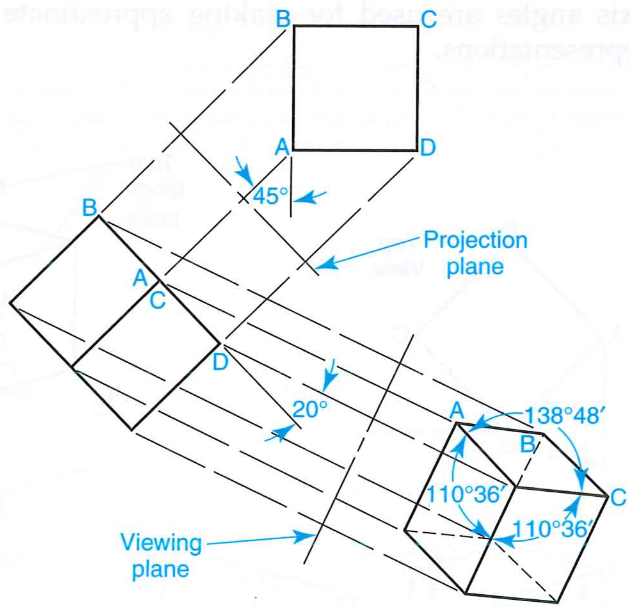


Figure 11-33. Using the successive auxiliary view method to construct a dimetric projection.

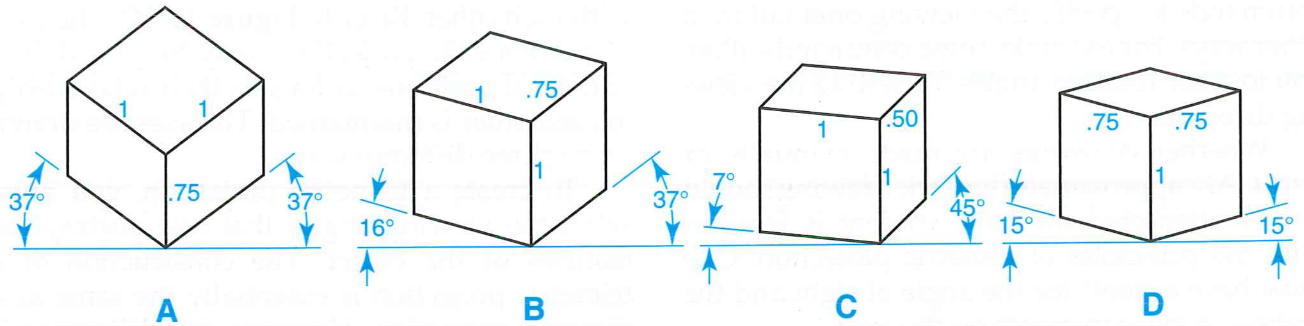


Figure 11-34. Common axis angle and scale combinations used for constructing approximate dimetric drawings.

drawings are shown in **Figure 11-34**, along with suggested scales for the axes.

In CAD drafting, dimetric drawings can be created using several different methods and tools. On a 2D drawing, the dimetric axis lines can be drawn using polar coordinates and object snaps. You can also use polar tracking and polar snaps to enter scaled measurements along axes defined by preset angles.

As previously discussed, dimetric drawings may be more easily created by constructing 3D models and using viewing commands to establish the correct viewing angle. For more simple views, such as orthographic and isometric views, you can use the **View** command. For more complex views in 3D work, you can use the **Orbit** command. This command provides the most flexibility for setting the viewing direction of a 3D model. It allows you to rotate the model dynamically by directing the pointing device and using controls on screen. This provides a quick way to display an approximate dimetric drawing. See **Figure 11-35**. Depending on the program, you may be able to use other

Figure 11-35. A dimetric drawing can be created in CAD by constructing a 3D model and using 3D viewing commands to set the viewing direction. Note the difference between the two views shown here. A—A dimetric drawing of a mechanical assembly. B—An isometric view of the same model shown for reference.

commands to specify the viewing orientation in other ways. For example, some commands allow you to enter rotation angles for setting the viewing direction.

Whether drawings are made manually or with CAD, approximate dimetric drawing should not be attempted until the student is familiar with the principles of dimetric projection. One must have a "feel" for the angle of sight and the scaling of measurements on the axes.

Trimetric Projection and Trimetric Drawings

In a *trimetric projection,* all three faces make different angles with the plane of projection. In addition, the three axes make different angles with each other. Refer to **Figure 11-4C**. The axes of axonometric projections may be placed in a variety of positions, as long as their relationship to each other is maintained. The axes are drawn using three different scales.

To create a trimetric projection, you must select the viewing angles that best portray the features of the object. The construction of a trimetric projection is essentially the same as a dimetric projection. However, the difference is that no two axes or surfaces are viewed at the same angle on the plane of projection.

Constructing a trimetric projection

The same procedure for constructing a dimetric projection can be used for a trimetric projection, **Figure 11-36**. However, the object is

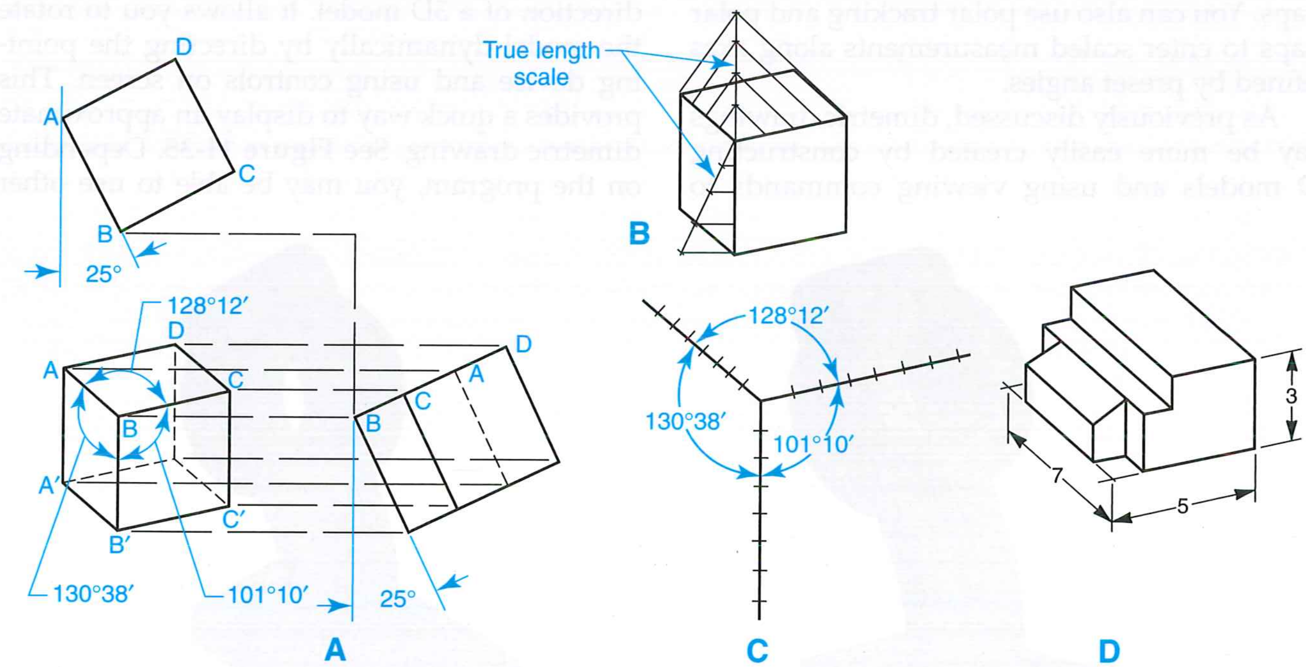


Figure 11-36. Constructing a trimetric projection. A—A projection of a cube is generated from the top and side views. Note the rotation angles used for revolving the object in the top and side views. B—Scale measurements are laid off as divisions on the trimetric axes. C—The trimetric scale is constructed. D—A trimetric projection of an object drawn at the scale used for the cube. Compare this example to **Figure 11-32D**.

inclined at unequal angles on the viewing plane, **Figure 11-36A**. This example shows a trimetric projection of a cube. The trimetric scale is constructed in the same manner as the dimetric scale, except a scale must be developed for each axis, **Figure 11-36B** and **Figure 11-36C**. The object shown in **Figure 11-32D** has been constructed as a trimetric projection in **Figure 11-36D**.

Constructing an approximate trimetric drawing using manual and CAD methods

An approximate trimetric drawing takes less time to develop than a trimetric projection. Common axis angle and scale combinations for approximate trimetric drawings are illustrated in **Figure 11-37**. The construction of an approximate trimetric drawing is similar to that of an approximate dimetric drawing. The same drafting instruments are used in manual drafting, and the same drawing and viewing commands are used in CAD drafting. However, do not attempt trimetric drawing until thoroughly familiar with true trimetric projection.

Constructing dimetric and trimetric circles

Circles appear as ellipses in dimetric and trimetric drawings. The major axis of the ellipse appears as a true length line in both dimetric and trimetric drawings.

In manual drafting, ellipses can be constructed using one of several methods. The four-center approximate method for constructing isometric ellipses is satisfactory for dimetric drawing planes where the scale is the same on both edges. On dimetric and trimetric drawings, ellipses may be drawn by the coordinate plotting method on the axis planes.

However, the most satisfactory method of drawing ellipses in manual dimetric and trimetric drawing is to first find the angle that a circle is viewed from in a particular plane. Then select the appropriate ellipse template and draw the ellipse. The viewing angle can be determined by projecting auxiliary views. Auxiliary views are discussed in Chapter 12. To determine the ellipse angle, identify the angle between the edge view of the principal planes in the dimetric or trimetric projection and the line of sight, **Figure 11-38**.

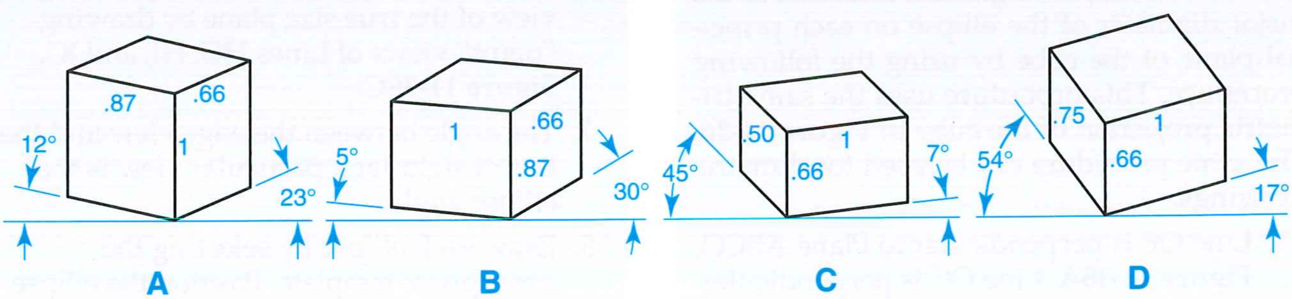


Figure 11-37. Common axis angle and scale combinations used for constructing approximate trimetric drawings.

The ellipse angles for a dimetric drawing are identical for two of the axis planes and different for the third axis plane. The ellipse angles for a trimetric drawing differ for each of the three axis planes.

In CAD drafting, as with other dimetric and trimetric drawing applications, it is typically easier to construct objects with circular features by drawing 3D models and displaying the appropriate view. When the model is rotated, circular features appear in the correct orientation. Refer to **Figure 11-35**. If you are working in 3D and adding circular features after the model is drawn, you can draw them in their correct orientation by creating user coordinate systems to establish drawing planes that are parallel to object faces.

Construct Circles in a Dimetric or Trimetric Drawing

Given a trimetric projection of a cube, you can find the ellipse angle and direction of the major diameter of the ellipse on each principal plane of the cube by using the following procedure. This procedure uses the same trimetric projection of the cube in **Figure 11-36**. The same procedure can be used for dimetric drawings.

1. Line OE is perpendicular to Plane ABCO, **Figure 11-38A**. Line OC is perpendicular to Plane AOEF. Line OA is perpendicular to Plane OCDE. (This simply means that the planes of the cube are perpendicular to each other.)
2. Construct true length lines GH, HJ, and JG on each plane by drawing them perpendicular to extensions of Lines OC, OA, and OE, **Figure 11-38B**. When two lines that are known to be perpendicular appear on the drawing as perpendicular, one or both lines are true length.
3. The intersections of the true length lines form a true size plane (Plane GHJ). A plane whose edges appear true length will appear true size.
4. Plane GHJ is a frontal plane (parallel to the viewing plane). This plane will project as a vertical edge in the side view.
5. To find the position of the 90° angle of the cube that is between Plane GHJ and the viewing plane, construct a semicircle with a diameter equal in length to the edge view of Plane GHJ. Then project Point 0 (the vertex of the 90° angle) to the semicircle. Inscribe the position of the corner of the cube. (Lines extending from the endpoints of the diameter of a semicircle joined at a point on the semicircle form a right angle.)
6. Draw auxiliary views showing the edge view of the true size plane by drawing "point" views of Lines HG, HJ, and JG, **Figure 11-38C**.
7. The angle between the edge view and the line of sight for a particular view is the ellipse angle.
8. Draw each ellipse by selecting the appropriate template. Position the ellipse template so the major diameter is parallel to the true length line on that particular plane, **Figure 11-38D**.

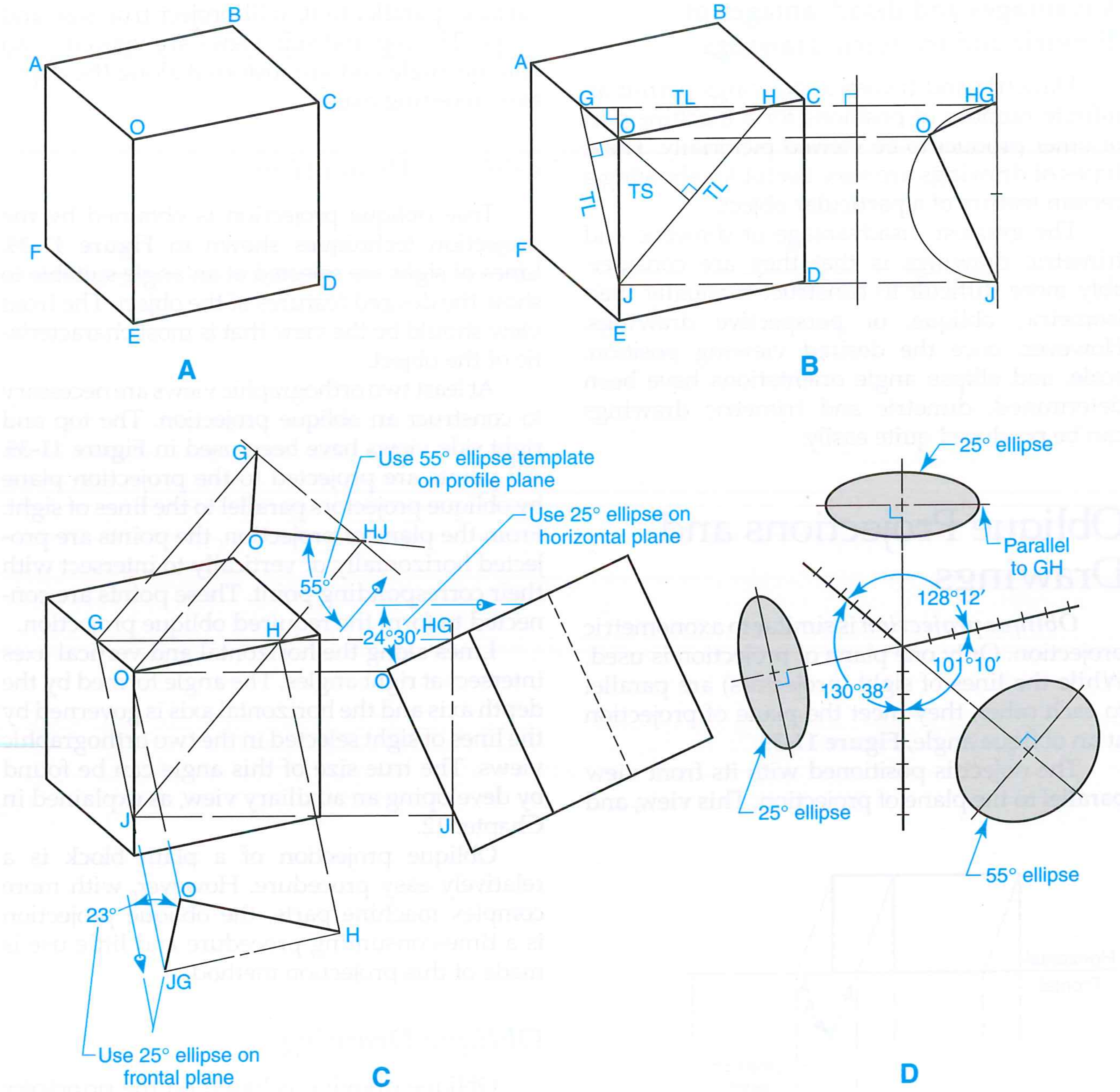


Figure 11-38. Determining ellipse angles for circles in dimetric and trimetric drawings.

Advantages and disadvantages of dimetric and trimetric drawings

Dimetric and trimetric drawings permit an infinite number of positions for a machine part or other product to be viewed pictorially. These types of drawings are very useful for showing a certain feature of a particular object.

The greatest disadvantage of dimetric and trimetric drawings is that they are considerably more difficult to construct manually than isometric, oblique, or perspective drawings. However, once the desired viewing position, scale, and ellipse angle orientations have been determined, dimetric and trimetric drawings can be produced quite easily.

Oblique Projections and Drawings

Oblique projection is similar to axonometric projection. Only one plane of projection is used. While the lines of sight (projectors) are parallel to each other, they meet the plane of projection at an oblique angle, **Figure 11-39**.

The object is positioned with its front view parallel to the plane of projection. This view, and surfaces parallel to it, will project true size and shape. The top and side views are viewed at an oblique angle and are distorted along the depth axis (receding axis).

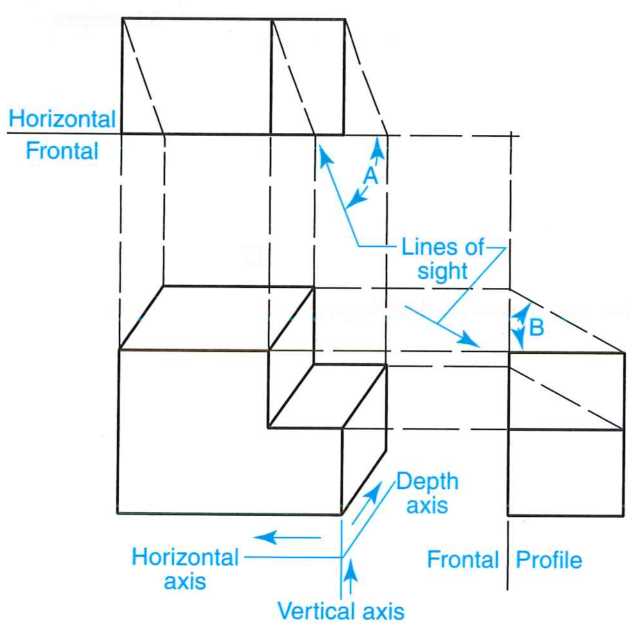


Figure 11-39. An oblique projection is developed from at least two orthographic views. The front view is positioned parallel to the projection plane.

Oblique Projection

True oblique projection is obtained by the projection techniques shown in **Figure 11-39**. Lines of sight are selected at an angle suitable to show the desired features of the object. The front view should be the view that is most characteristic of the object.

At least two orthographic views are necessary to construct an oblique projection. The top and right side views have been used in **Figure 11-39**. All points are projected to the projection plane by oblique projectors parallel to the lines of sight. From the plane of projection, the points are projected horizontally or vertically to intersect with their corresponding point. These points are connected to form the required oblique projection.

Lines along the horizontal and vertical axes intersect at right angles. The angle formed by the depth axis and the horizontal axis is governed by the lines of sight selected in the two orthographic views. The true size of this angle can be found by developing an auxiliary view, as explained in Chapter 12.

Oblique projection of a plain block is a relatively easy procedure. However, with more complex machine parts, the oblique projection is a time-consuming procedure and little use is made of this projection method.

Oblique Drawing

Oblique drawing is based on the principles of oblique projection, although the construction of an oblique drawing is much faster and often yields more satisfactory results than an oblique projection itself.

There are three types of oblique drawings: cavalier, cabinet, and general. The three differ only in the ratio of the scales used on the front axes and the receding axis.

A ***cavalier oblique*** is based on an oblique projection. The lines of sight in a cavalier oblique make an angle of 45° with the plane of projection. In a true cavalier projection, the receding lines project in their true length. Therefore, a

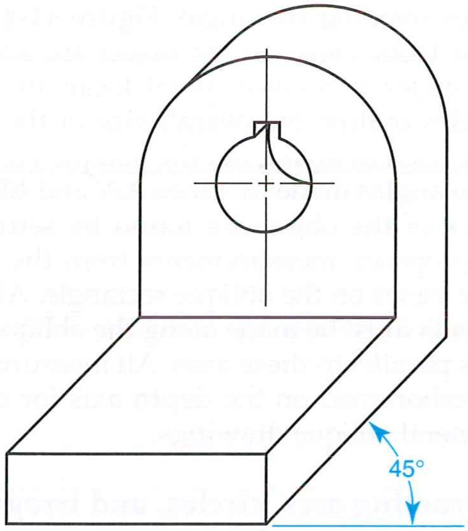


Figure 11-40. In a cavalier oblique drawing, the receding lines are typically drawn at 45°. All lines appear true length.

cavalier oblique drawing is usually drawn with a receding axis of 45° (approximating a line of sight of 45°) and the same scale is used on all three axes, **Figure 11-40**.

Using an equal scale on all axes is the principal advantage of the cavalier oblique drawing over other types. However, it presents a distorted appearance for objects when the depth approaches or exceeds the width. Unless otherwise indicated, an oblique drawing refers to a cavalier oblique.

A ***cabinet oblique*** is also based on an oblique projection. The lines of sight are inclined to the plane of projection. However, in this type of projection, the receding lines project one-half their true length. Therefore, the scale on the receding axis of the cabinet oblique drawing is one-half that for the other axes, **Figure 11-41**. Common axis angles used for the receding axis are 30°, 45°, and 60°.

A ***general oblique*** is based on an oblique projection as well. The lines of sight are inclined to the plane of projection. The scale on the receding axis is greater than one-half but less than full size. The receding axis may be drawn at any angle between 0° and 90°, **Figure 11-42**.

While oblique drawings may be drawn with a receding axis at any angle between 0° and 90°, the most common angles are 45° and 30°. The three types of oblique drawings differ mainly in the ratio of the scale used on the receding axis compared to the other axes, **Figure 11-43**. In manual drafting, the oblique axes can easily be drawn with triangles. In CAD drafting, the oblique axes can be drawn using polar coordinates or polar tracking and snaps. As with other pictorial drawing applications in CAD drafting, it may be easier to create the geometry for an oblique drawing as a 3D model and use viewing commands to establish the 3D viewing angle.

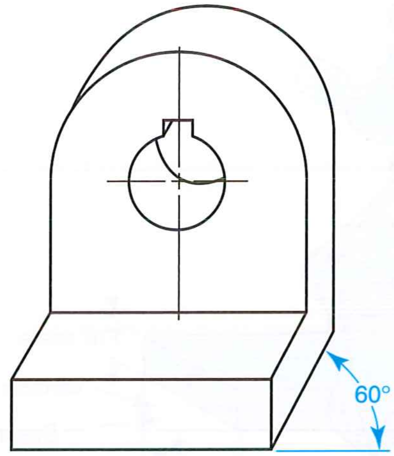


Figure 11-41. In a cabinet oblique drawing, receding lines appear half scale, while all other lines appear true length.

Constructing angles in oblique drawings

Angles that are shown true size in the frontal orthographic view will appear true size in the frontal plane of an oblique drawing. Angles that lie in planes other than the frontal plane must be located by finding the endpoints of

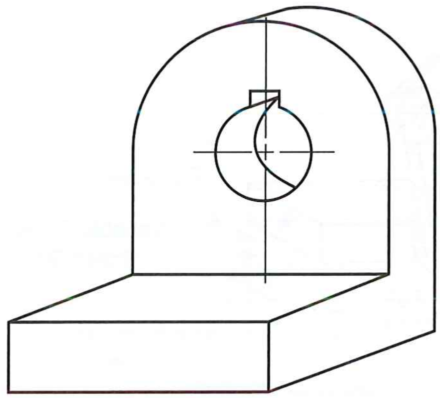


Figure 11-42. In a general oblique drawing, receding lines are drawn at any angle between 0° and 90°. The receding lines appear somewhere between half scale and full scale.

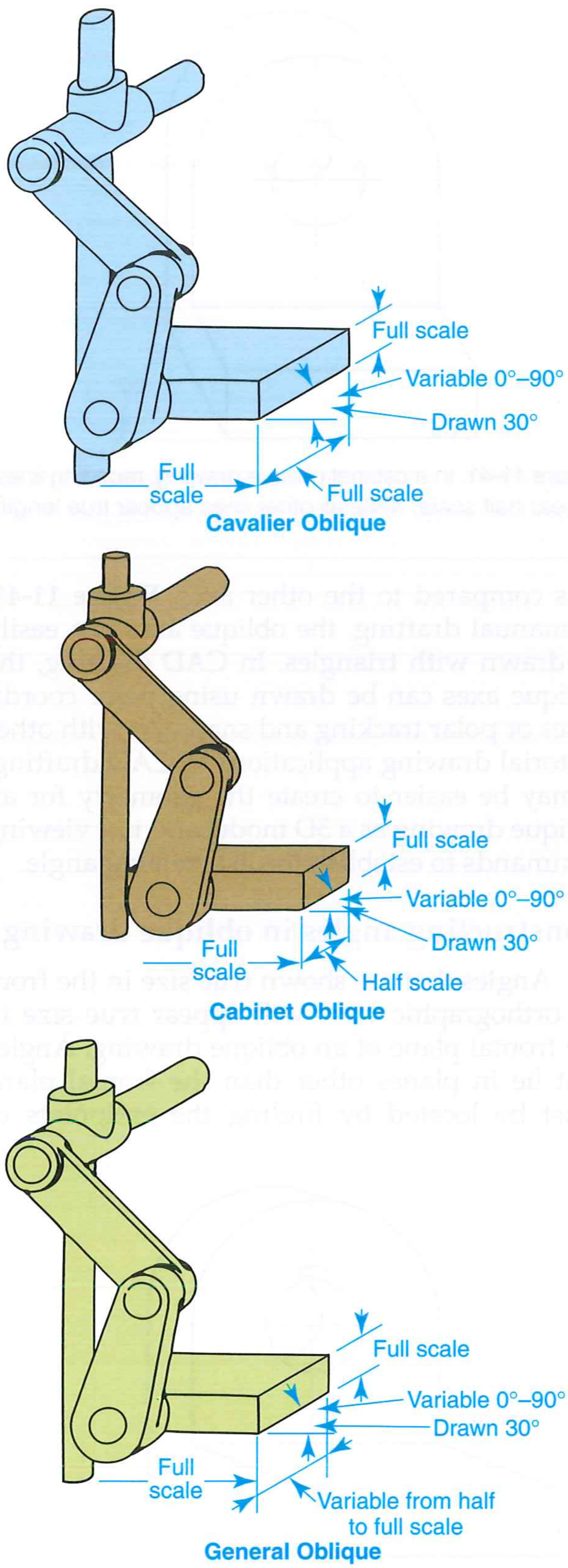


Figure 11-43. The three types of oblique drawings yield different results. The appropriate type should be selected to best portray the object.
(American National Standards Institute)

the lines forming the angle, **Figure 11-44.** The top and front views of the object are enclosed in rectangles to identify point locations. These rectangles outline the overall size of the object and are used in laying out the oblique view.

The angles made by Lines AA′ and BB′ with the back of the object are found by setting off the appropriate measurements from the orthographic views on the oblique rectangle. All measurements must be made along the oblique axes, or lines parallel to these axes. All measurements are foreshortened on the depth axis for cabinet and general oblique drawings.

Constructing arcs, circles, and irregular curves in oblique drawings

Arcs and circles located in the frontal plane of an oblique drawing will appear in their true shape. On other oblique planes, the four-center approximate method or the coordinate method may be used for drawing arcs and circles manually. When arcs and circles are located in the principal cavalier oblique planes other than the frontal plane, they may be drawn manually using the four-center approximate method, **Figure 11-45A.** Arcs and circles for cabinet and general oblique drawings made in manual drafting are first drawn in their true shape in the frontal plane. They are then transferred to the other oblique planes using the coordinate method and oblique "squares" due to the foreshortening of the depth axis, **Figure 11-45B.** Irregular curves are also transferred to oblique drawings by means of the coordinate method, **Figure 11-45C.**

In CAD drafting, different drawing methods are available for constructing arcs and circles on oblique planes, depending on the type of oblique drawing and the receding axis scale. On cavalier oblique drawings where the receding axis angle is 30°, the **Ellipse** command and isometric snap can be used to draw circles and arcs. On other oblique drawings, circles, arcs, and irregular curves can be drawn by transferring points to an oblique plane from the frontal plane using the **Copy** command and polar tracking to "offset" the oblique axis lines. Coordinates can be plotted along the copied lines to establish points for the curve, and the curve can then be drawn by using the **Spline** command. However, as previously discussed, it may be easier to create the drawing as a 3D model and use viewing commands to set the viewing direction to an oblique view.

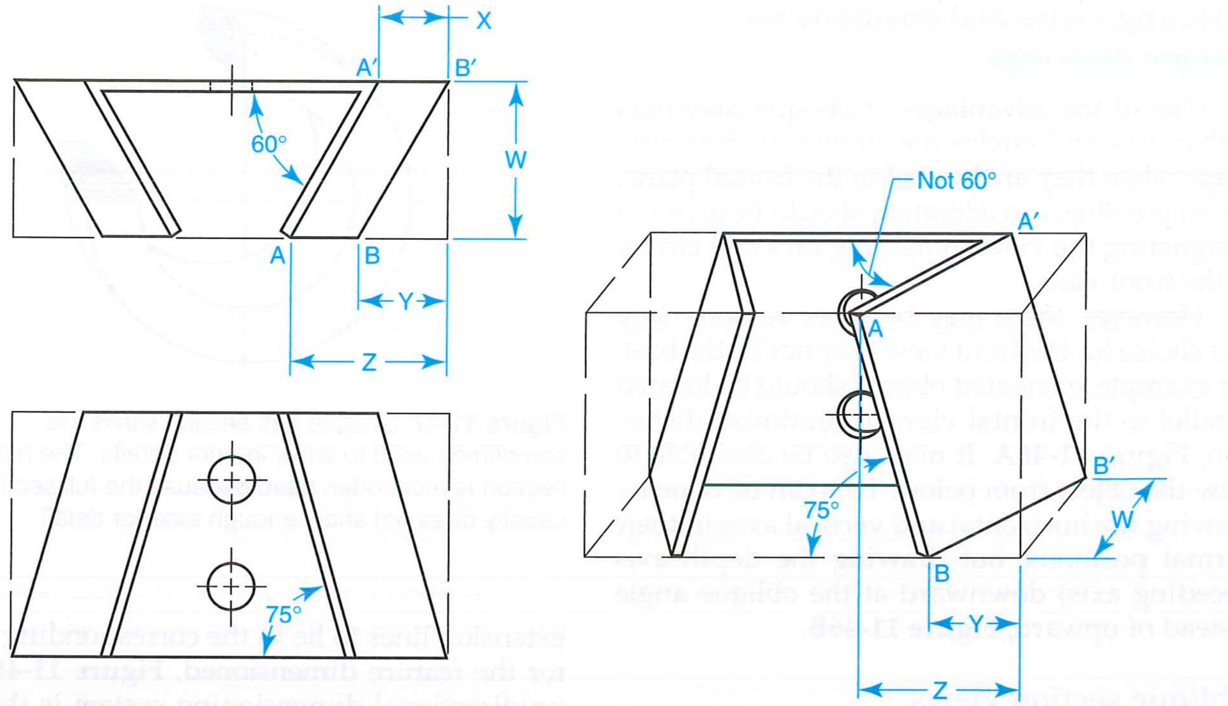


Figure 11-44. Angles that lie in the frontal orthographic view can be laid off directly in an oblique drawing. Angles that lie in any other plane must be located by first finding their endpoints. The endpoints must be located by measuring parallel to the oblique axes.

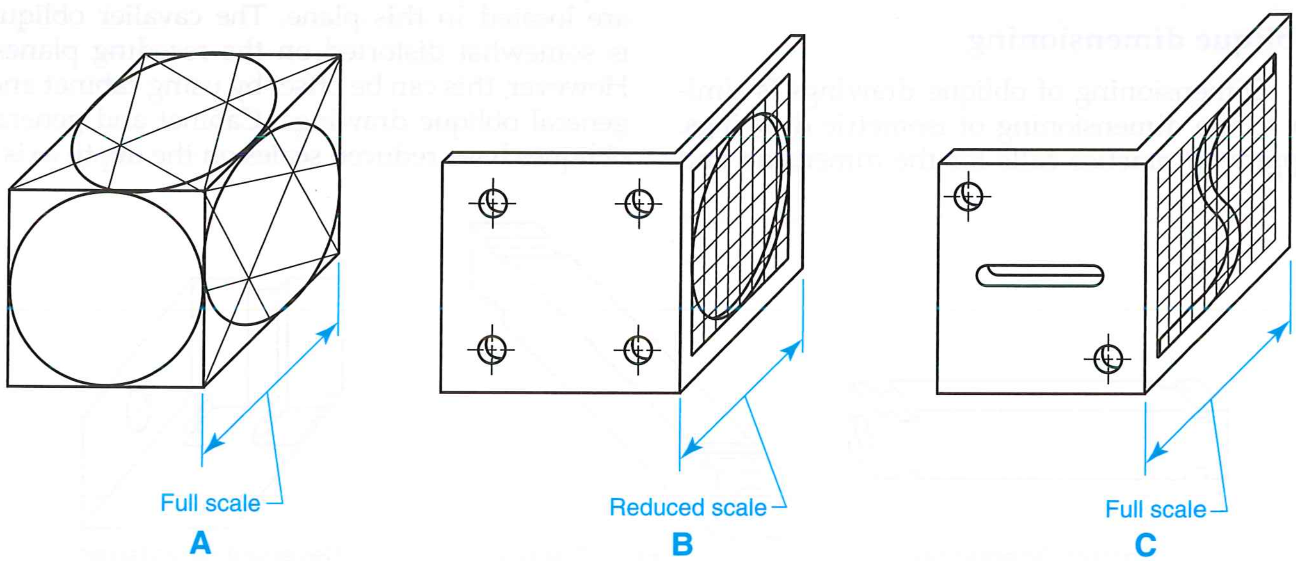


Figure 11-45. Arcs, circles, and irregular curves that lie in the frontal plane of an oblique drawing are drawn true size. These can be laid off directly. Arcs, circles, and irregular curves that lie in the oblique planes must be located differently. A—On cavalier oblique drawings, the four-center approximate method can be used to locate arcs and circles on the oblique planes. B—Arcs and circles can also be located by the coordinate method. C—The coordinate method can also be used to locate irregular curves.

Selecting views and positions for oblique drawings

One of the advantages of oblique drawings is that arcs and circles are drawn in their true shape when they are located in the frontal plane. When possible, consideration should be given to designating the view containing arcs and circles as the front view.

However, there may be other reasons why this choice for the front view may not be the best. For example, elongated objects should be located parallel to the frontal view to minimize distortion, **Figure 11-46A**. It may also be desirable to view the object from below. This can be done by drawing the horizontal and vertical axes in their normal positions, but drawing the depth axis (receding axis) downward at the oblique angle instead of upward, **Figure 11-46B**.

Oblique section views

Section views may be used in an oblique drawing to provide a better view of the interior detail, **Figure 11-47**. The half section is used more often than the full section. The full section usually does not show sufficient exterior detail of a part. Correct positioning of the part is as important for oblique sections as it is for exterior oblique drawings.

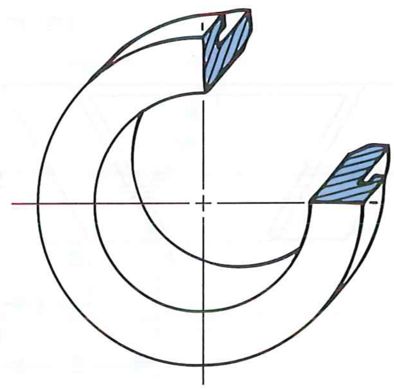


Figure 11-47. Oblique half section views are sometimes used to show interior details. The half section is most often used because the full section usually does not show enough exterior detail.

Oblique dimensioning

Dimensioning of oblique drawings is similar to the dimensioning of isometric drawings. Approved practice calls for the dimension and extension lines to lie in the corresponding plane for the feature dimensioned, **Figure 11-48**. The unidirectional dimensioning system is the preferred practice.

Advantages and disadvantages of oblique drawings

The oblique drawing has the advantage of showing an object in its true shape in the frontal plane. Therefore, it may be a faster method of pictorial presentation when arcs and circles are located in this plane. The cavalier oblique is somewhat distorted on the receding planes. However, this can be offset by using cabinet and general oblique drawings. Cabinet and general obliques have reduced scales on the depth axis.

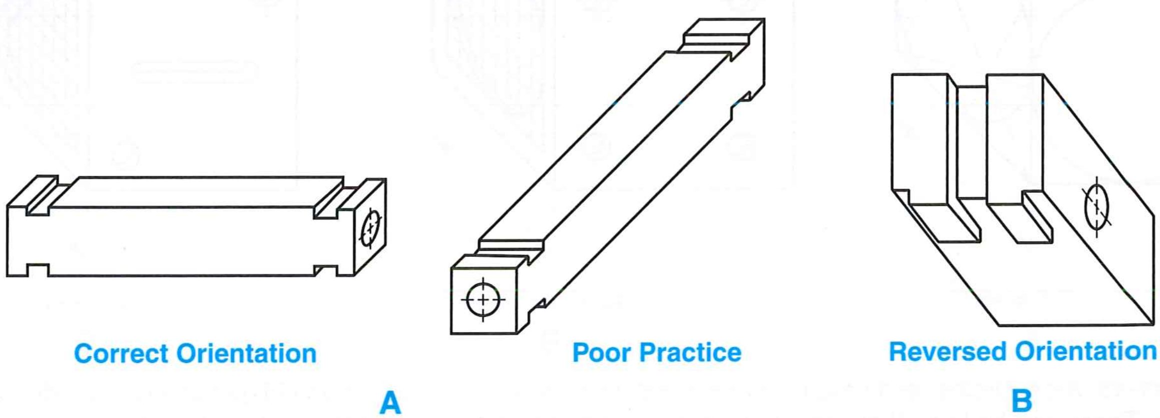


Figure 11-46. Orienting oblique drawings to show features correctly. A—Elongated objects should be located so that the long side is parallel to the viewing plane. This will minimize distortion. B—Occasionally, the bottom of an object needs to be shown. By reversing the direction of the depth axis, the bottom of the object can be shown.

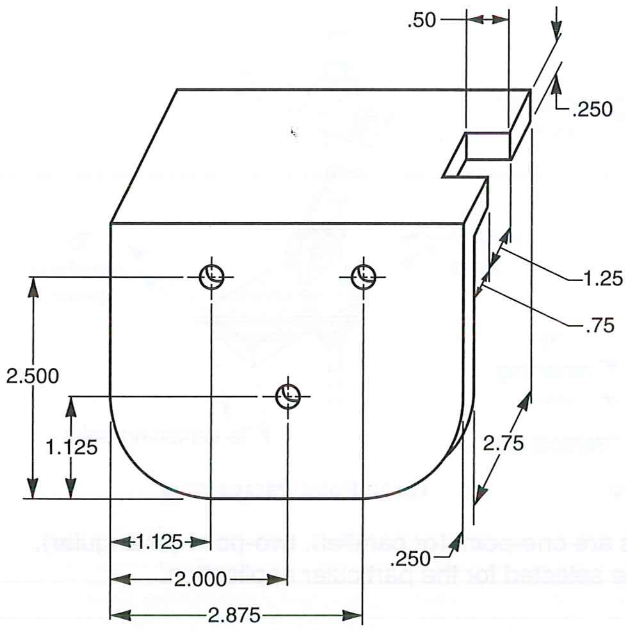


Figure 11-48. Dimensions on oblique drawings must be in the correct plane for the feature dimensioned.

A definite limitation of cabinet and general oblique drawings is that circular and curved features on the receding planes take time to develop. Long objects appear distorted when it is necessary to draw elongated features on the depth axis, particularly in cavalier oblique drawings. Another limitation of cabinet and general oblique drawings is that a second scale must be used on the depth axis.

Perspective Drawings

When compared to other types of pictorial drawings, a ***perspective drawing*** most nearly represents what is seen by the eye or camera. In the other types of pictorial drawings discussed in this chapter, parallel lines remain parallel. In perspective drawings, parallel lines tend to converge as they recede from a person's view. This reproduces the effect of looking at a real object or scene, **Figure 11-49**.

The three basic types of perspective drawings are one-point (parallel), two-point (angular), and three-point. These types are named for the number of vanishing points required in their construction, **Figure 11-50**.

The perspective drawing principles and methods presented in this chapter apply to manual drafting. In CAD drafting, perspective drawings are most typically generated from 3D models using 3D viewing commands. While perspective drawing layouts are mostly limited to manual drafting applications, it is important to study the principles of perspective drawing whether you are creating drawings manually or with a CAD system. Understanding these principles will improve your visualization skills and provide a reference when you are preparing pictorial views. Creating perspective views of 3D models is discussed later in this chapter.

Figure 11-49. The principles of perspective drawing make train tracks appear to come together in the distance. If a line is drawn along each track, the point of intersection is called a vanishing point. (Jack Klasey)

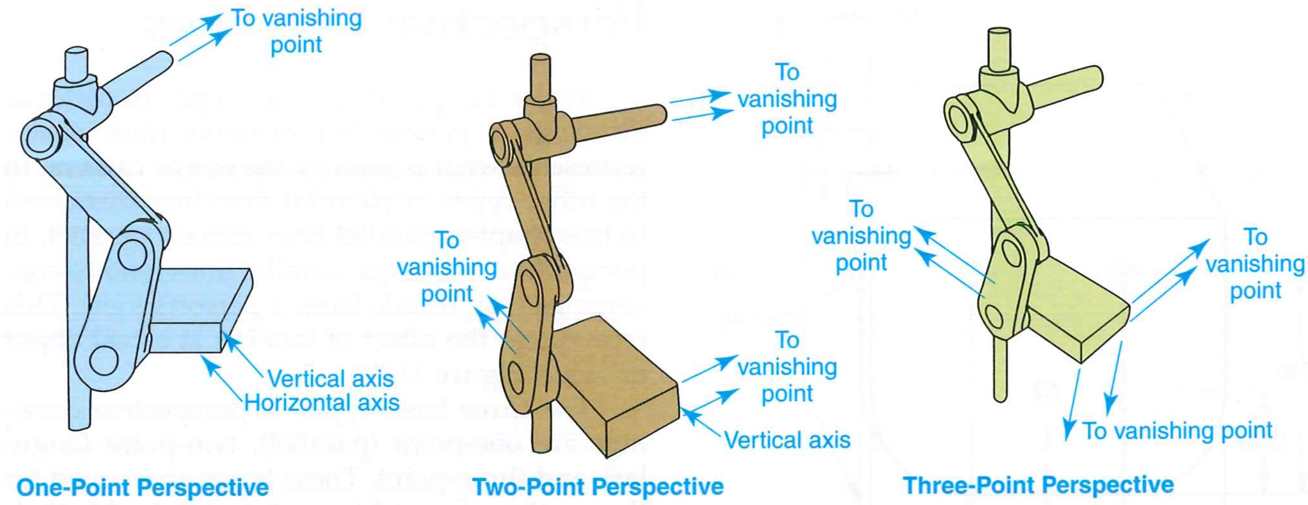


Figure 11-50. The three basic types of perspective drawings are one-point (or parallel), two-point (or angular), and three-point perspectives. The appropriate type should be selected for the particular application. (American National Standards Institute)

Terminology in Perspective Drawings

There are certain terms that must be defined before a discussion of perspective drawings can proceed. The terms that are commonly used in perspective drawing are discussed in the following sections and are shown in **Figure 11-51**.

Station point

A ***station point (SP)*** is an assumed point representing the position of the observer's eye. This is sometimes called the "point of sight." The location of this point greatly affects the perspective produced. To select the best view, locate the station point at a distance from the object to form a viewing angle of approximately 30°. Move the station point to the right or left, depending on the particular view of the object to be emphasized. The elevation of the station point is on the horizon line and determines whether the object is viewed from above, on center, or below center.

Vanishing points

Vanishing points (VP) are points in space where all parallel lines meet. (These lines are not parallel to the picture plane.) The vanishing points for horizontal parallel lines are always located on the horizon line.

Visual rays

Visual rays are lines of sight from the object to the station point. They represent the light rays that produce an image in the viewer's eye.

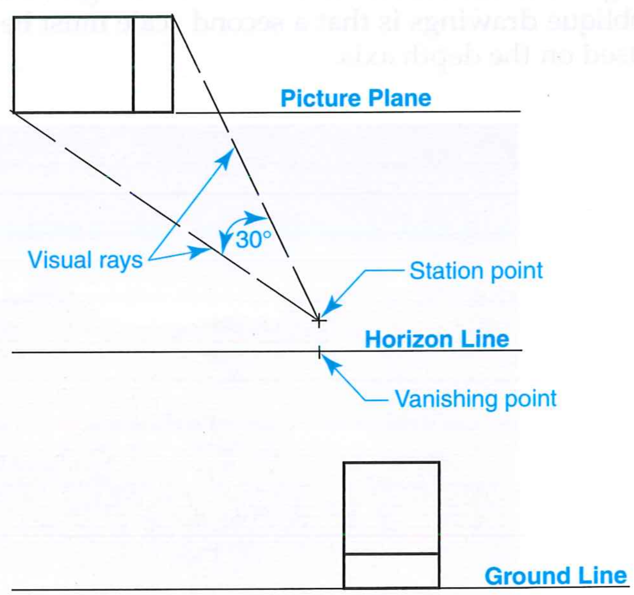


Figure 11-51. Common terms used to describe perspective drawing layouts. Shown is a layout of a one-point, or parallel, perspective. This type of perspective has one vanishing point located on the horizon line.

Picture plane

A ***picture plane (PP)*** is the projection plane that the perspective is viewed from. It may be aligned with, in front of, or behind the object. The picture plane is a vertical plane for most perspectives. The picture plane appears as a line in the top view and as a plane in the front view. However, it can appear in any position. For example, for a "bird's eye" perspective, the plane would be horizontal in the top view and appear as an edge in the front view.

Horizon line

The ***horizon line (HL)*** is a horizontal line that the vanishing points are located on and where receding lines tend to converge. The horizon line can appear at any level. It can be located above, on (behind), or below the object to produce the perspective view desired. The effects of various levels of the horizon line are illustrated in **Figure 11-52**.

Ground line

The ***ground line (GL)*** is the base line or position of rest for the object.

One-Point Perspective Drawings

A ***one-point perspective*** has only one vanishing point. In a one-point perspective, the frontal plane of the object is parallel to the picture plane. A one-point perspective is also known as a *parallel perspective*. One-point perspective drawings are used in many instances to help in illustrating the interior of a room or structure.

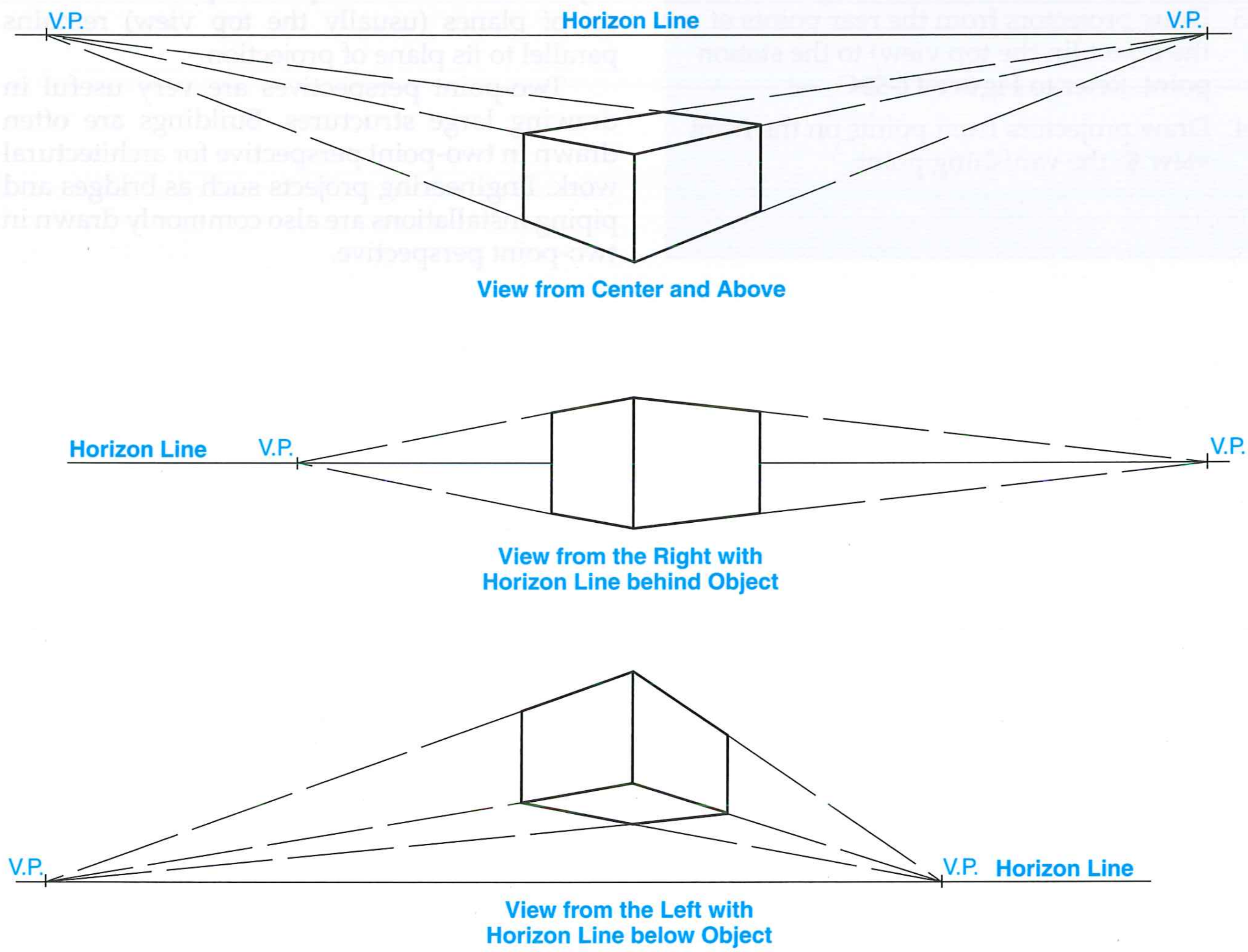


Figure 11-52. The horizon line can appear above, on (behind), or below the object. The view can be oriented so that it is on the center, to the right, or to the left of the object.

Construct a One-Point Perspective Drawing

Given the top view, side view, station point, horizon line, and ground line, the construction procedure for one-point perspective drawing is as follows. See **Figure 11-53**.

1. Locate the vanishing point on the horizon line directly below the station point. Refer to **Figure 11-53A**.
2. Construct the frontal plane of the object by projections from the top and side views. This will be a true size projection since the surface lies in the picture plane. Refer to **Figure 11-53B**.
3. Draw projectors from the rear points of the object (in the top view) to the station point. Refer to **Figure 11-53C**.
4. Draw projectors from points on the front view to the vanishing point.
5. Construct the depth of the perspective view by drawing vertical projectors from points where the projectors from the top view to the station point cross the picture plane. Refer to **Figure 11-53D**. These vertical projectors intersect the projectors to the vanishing points to form a one-point perspective.

Two-Point Perspective Drawings

In a ***two-point perspective,*** two sets of principal planes of the object are inclined to the picture plane. Parallel lines of the inclined sets converge at two vanishing points on the horizon line. This type of perspective is sometimes called an *angular perspective* because of the angle the object makes with the picture plane. The third set of planes (usually the top view) remains parallel to its plane of projection.

Two-point perspectives are very useful in drawing large structures. Buildings are often drawn in two-point perspective for architectural work. Engineering projects such as bridges and piping installations are also commonly drawn in two-point perspective.

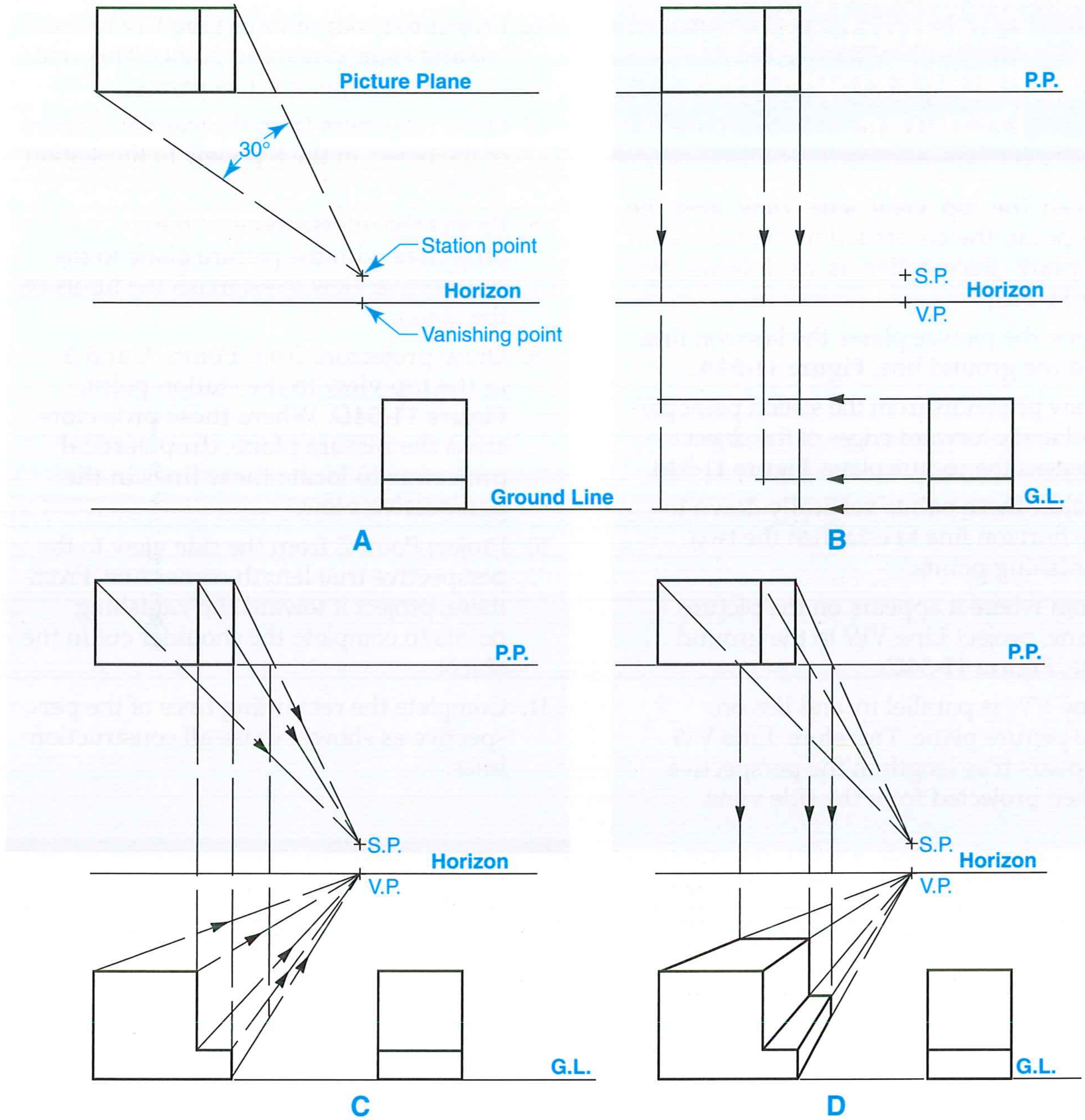


Figure 11-53. Constructing a one-point perspective drawing.

Construct a Two-Point Perspective Drawing

Given the top view, side view, and the station point, the construction procedure for a two-point perspective is as follows. See **Figure 11-54**.

1. Draw the picture plane, the horizon line, and the ground line, **Figure 11-54A**.
2. Draw projectors from the station point parallel to the forward edges of the object to intersect the picture plane, **Figure 11-54B**.
3. Project these points vertically down to the horizon line to establish the two vanishing points.
4. From where it appears on the picture plane, project Line VW to the ground line, **Figure 11-54C**.
5. Line VW is parallel to, and lies on, the picture plane. Therefore, Line VW appears true length in the perspective when projected from the side view.
6. Project the endpoints of Line VW to the left and right vanishing points. This will establish two perspective planes.
7. Draw projectors from the exterior corners of the object in the top view to the station point.
8. Project the intersections of these projectors with the picture plane to the perspective view to establish the limits of the object.
9. Draw projectors from Points X and Y in the top view to the station point, **Figure 11-54D**. Where these projectors cross the picture plane, drop vertical projectors to locate these lines in the perspective view.
10. Project Point Z from the side view to the perspective true length corner line. From there, project it toward the vanishing points to complete the shoulder cut in the object.
11. Complete the remaining lines of the perspective as shown. Erase all construction lines.

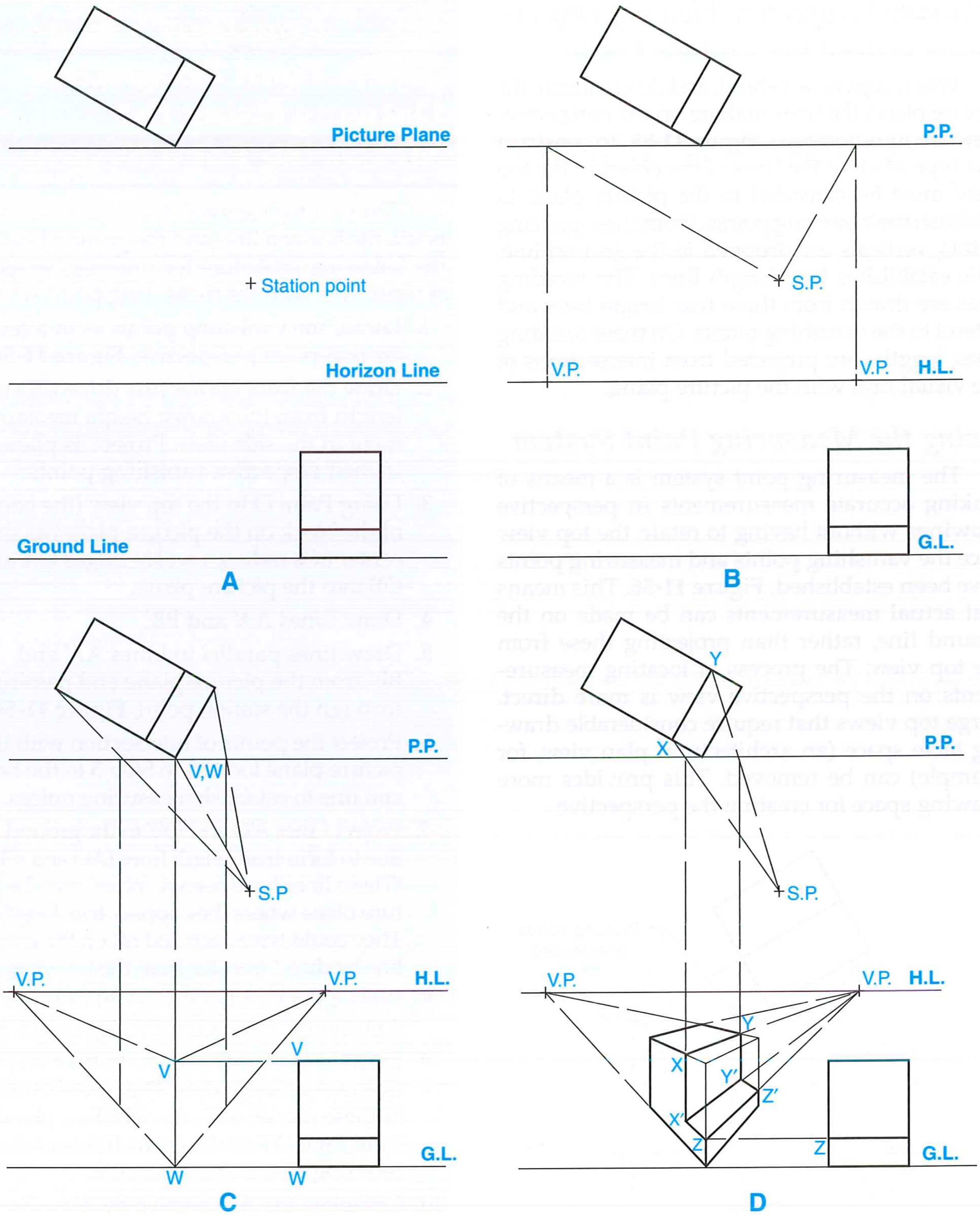


Figure 11-54. Constructing a two-point perspective drawing.

Drawing Perspective Views of Objects Lying behind the Picture Plane

When objects lie behind, and do not touch, the picture plane, the lines making up the perspective view are foreshortened, **Figure 11-55**. To construct this type of view, the lines of the object in the top view must be extended to the picture plane to establish their piercing points. From these piercing points, verticals are dropped to the ground line. This establishes true length lines. The receding lines are drawn from these true length lines and extend to the vanishing points. On these receding lines, lengths are projected from intersections of the visual rays with the picture plane.

Using the Measuring Point System

The measuring point system is a means of making accurate measurements in perspective drawings without having to retain the top view once the vanishing points and measuring points have been established, **Figure 11-56**. This means that actual measurements can be made on the ground line, rather than projecting these from the top view. The process of locating measurements on the perspective view is more direct. Large top views that require considerable drawing table space (an architectural plan view, for example) can be removed. This provides more drawing space for creating the perspective.

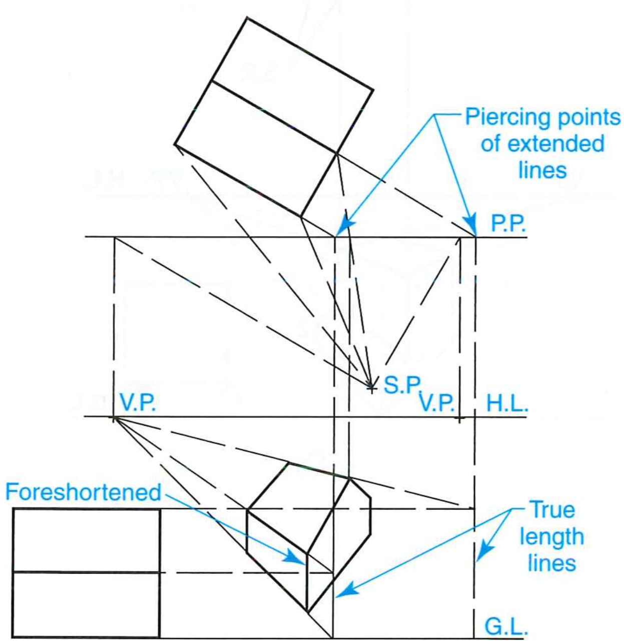


Figure 11-55. In perspective views of objects lying behind the picture plane, the object lines are foreshortened.

Construct a Two-Point Perspective Drawing Using the Measuring Point System

Given the top view and its position, the station point, the horizon line, and the ground line, use the following procedure for drawing two-point perspectives with the measuring point system.

1. Locate the vanishing points as in a regular two-point perspective, **Figure 11-56A**.
2. Draw the front corner line (Line OE) true length from the known height measurement in the side view. Project its planes to their respective vanishing points.
3. Using Point O in the top view (the corner of the block on the picture plane) as the center of a radius, revolve Edges OA and OB into the picture plane.
4. Draw Lines AA′ and BB′.
5. Draw lines parallel to Lines AA′ and BB′ from the picture plane and passing through the station point, **Figure 11-56B**.
6. Project the points of intersection with the picture plane located in Step 5 to the horizon line to establish measuring points.
7. Project Lines A′O and OB′ to the ground line to form true length lines (AO and OB). (These lines have been revolved into the picture plane where they appear true length. They could have been laid off on the ground line by direct transfer from the top view.)
8. Project the true length height of Lines AD and BC from Line OE, **Figure 11-56C**.
9. Extend Planes AD and BC to their respective measuring points. The intersections of these planes with the receding planes from Line OE establish the limits of the receding planes from Line OE.
10. Complete the perspective by drawing the remaining vertical or receding lines.
11. Measurements for other features can be laid off true length on the ground line from known measurements in the top or side view. Refer to the shoulder cut formed by Lines XY and YZ in **Figure 11-56D**.

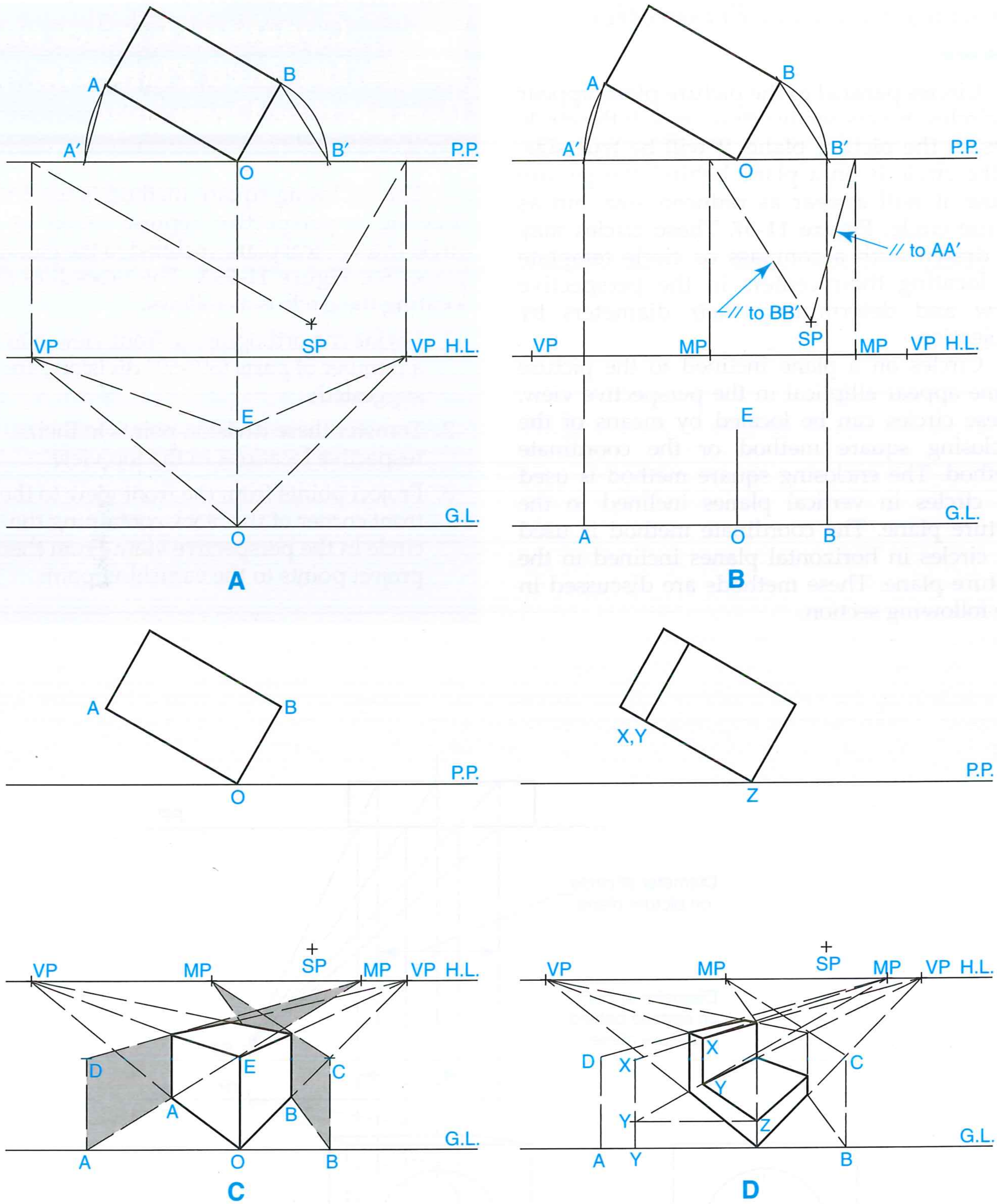


Figure 11-56. Using the measuring point system to construct a perspective drawing. This system is very useful for drawing large objects, such as buildings.

Drawing Circles in Perspective Views

Circles parallel to the picture plane appear as circles in perspective drawings. If the circle lays on the picture plane, it will be true size. If the circle is on a plane behind the picture plane, it will appear as reduced size, but as a true circle, **Figure 11-57**. These circles may be drawn with a compass or circle template by locating their centers in the perspective view and determining their diameters by projection.

Circles on a plane inclined to the picture plane appear elliptical in the perspective view. These circles can be located by means of the enclosing square method or the coordinate method. The enclosing square method is used for circles in vertical planes inclined to the picture plane. The coordinate method is used for circles in horizontal planes inclined to the picture plane. These methods are discussed in the following section.

Construct Circles on Inclined Planes in Perspective Drawings

The enclosing square method is used for drawing a perspective representation of a circle in a vertical plane inclined to the picture plane. See **Figure 11-58A**. The procedure for locating the circle is as follows.

1. Divide the orthographic front view into a number of parts (30°-60° divisions are suggested).
2. Transfer these division points to their respective locations in the top view.
3. Project points from the front view to the front corner of the block containing the circle in the perspective view. From there, project points to the vanishing point.

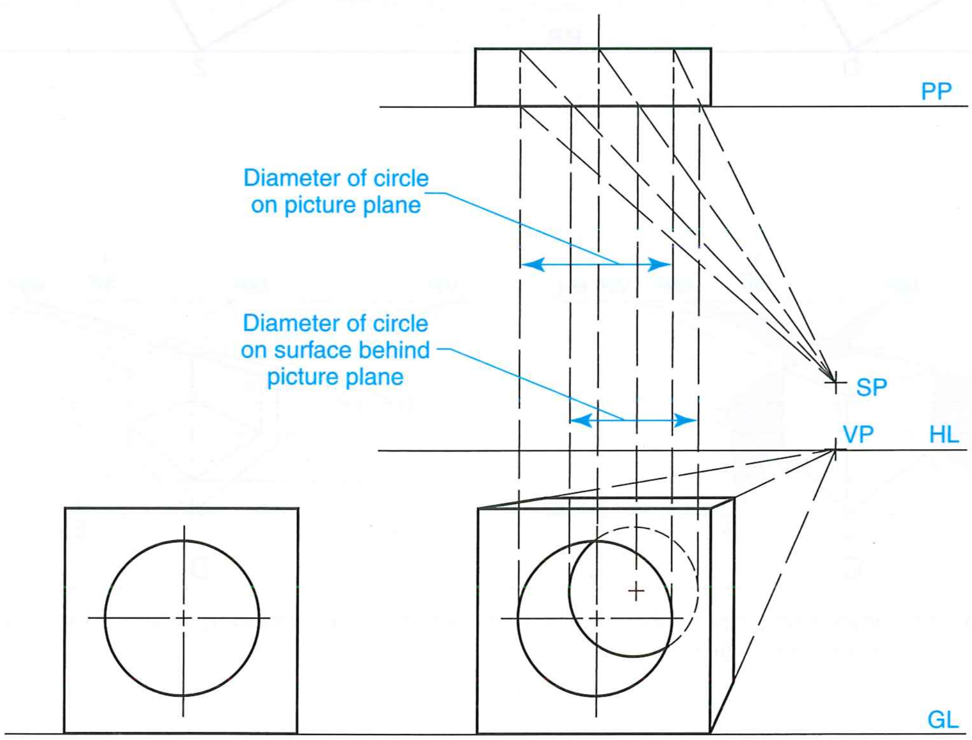
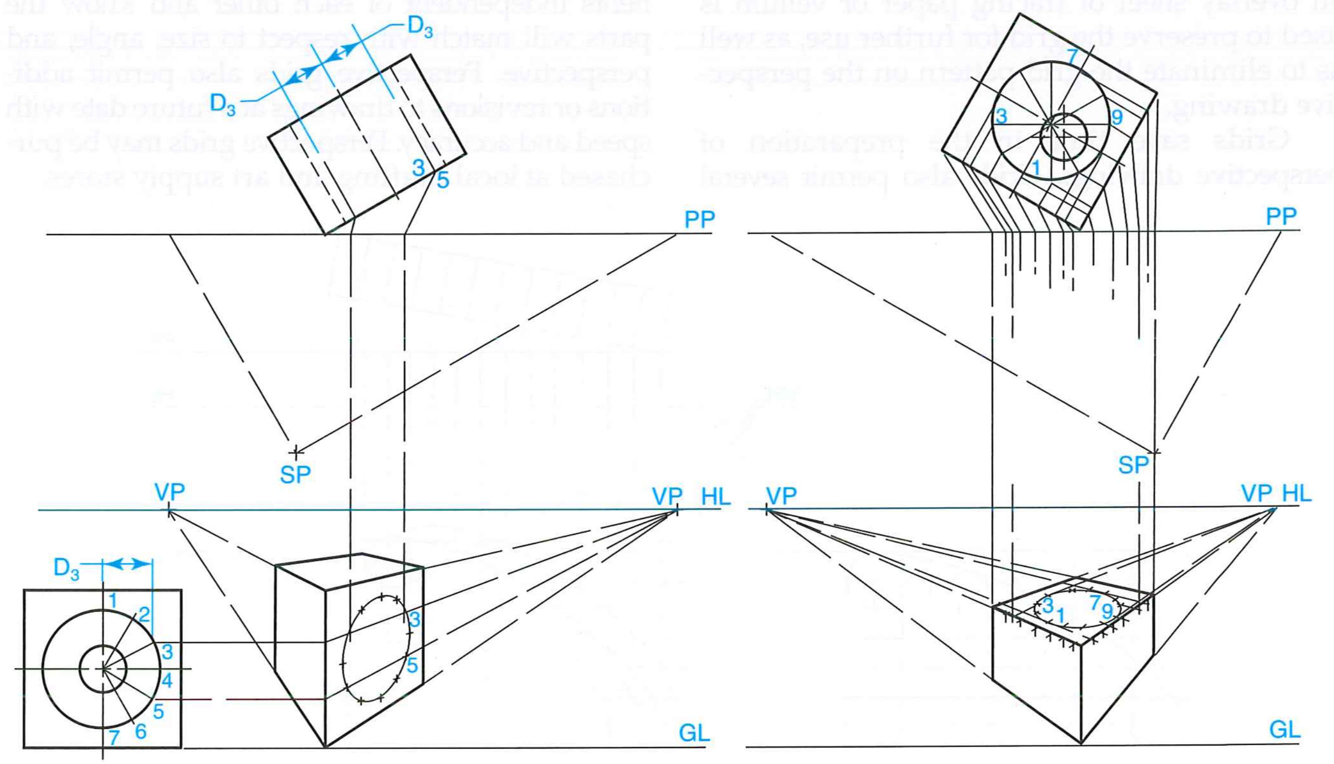


Figure 11-57. Circles on surfaces parallel to the picture plane will appear as circles in perspective drawings. However, only circles that appear on the picture plane will appear true size. All others will be foreshortened.

4. Project division points from the top view to the picture plane by visual rays to the station point. Also, project the division points from the picture plane, vertically, to the perspective view to intersect with their corresponding lines.
5. Draw the perspective ellipse with an irregular curve or an ellipse template.

The coordinate method is used for the construction of circles on horizontal surfaces in perspective drawings. See **Figure 11-58B.** The procedure for this construction is as follows.

1. Divide the circle in the top view into a number of parts (30°-60° divisions are suggested).
2. Project these division points to the front two edges of the block on lines parallel to the adjacent sides.
3. Establish the height of the block on the picture plane "corner" in the perspective view. (This will be true length since the corner is on the picture plane.) Draw receding lines to the vanishing points.
4. Project the division points from the top view to the picture plane by visual rays to the station point. Also, project the division points from the picture plane, vertically, to the perspective view to intersect with their corresponding lines on the front edges.
5. From these points of intersection on the front edges, draw receding lines to the two vanishing points. The points of intersection of the corresponding lines are points on the ellipse.
6. Draw the perspective ellipse using an irregular curve or an ellipse template.



Enclosing Square Method
A

Coordinate Method
B

Figure 11-58. Circles on surfaces inclined to the picture plane in perspective views can be constructed using the enclosing square method or the coordinate method.

Drawing Irregular Curves in Perspective Views

Irregular curves may be drawn in perspective using the coordinate method, **Figure 11-59**. Points are located along the curve in the orthographic views and projected to the picture plane and vertical true length line in the perspective.

Perspective Grids

A ***perspective grid*** is a drawing grid used to make accurate perspective drawings without having to establish (and project from) vanishing, measuring, and sighting points, **Figure 11-60**. There are many variations, including the cube grid for general purpose illustration, the one-point grid for interior views, the three-point oblique grid, the cylindrical grid for representing aircraft fuselages, and others.

Grids include a scale that measurements can be projected from. This maintains an accurate representation of proportion in the object being drawn. Instead of actually drawing on the grid, an overlay sheet of tracing paper or vellum is used to preserve the grid for further use, as well as to eliminate the grid pattern on the perspective drawing.

Grids save time in the preparation of perspective drawings. Grids also permit several drafters and illustrators to draw related components independent of each other and know the parts will match with respect to size, angle, and perspective. Perspective grids also permit additions or revisions to drawings at a future date with speed and accuracy. Perspective grids may be purchased at local drafting and art supply stores.

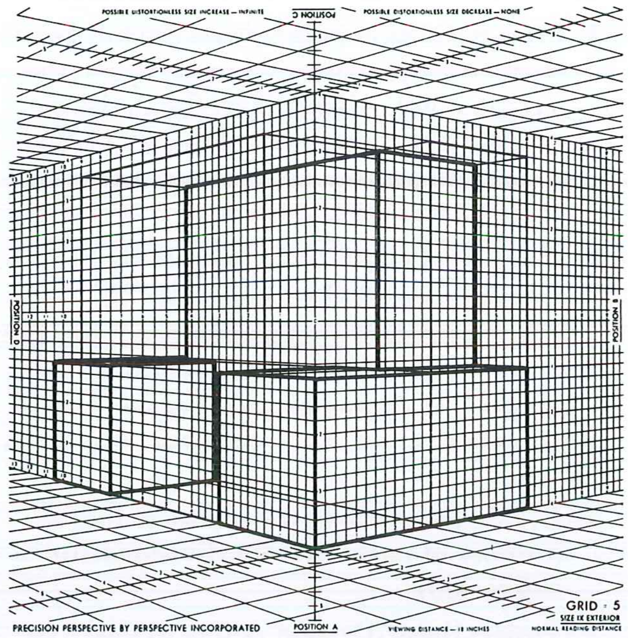


Figure 11-60. A perspective grid eliminates the need to establish vanishing, measuring, and sighting points. These points have already been established by the grid.

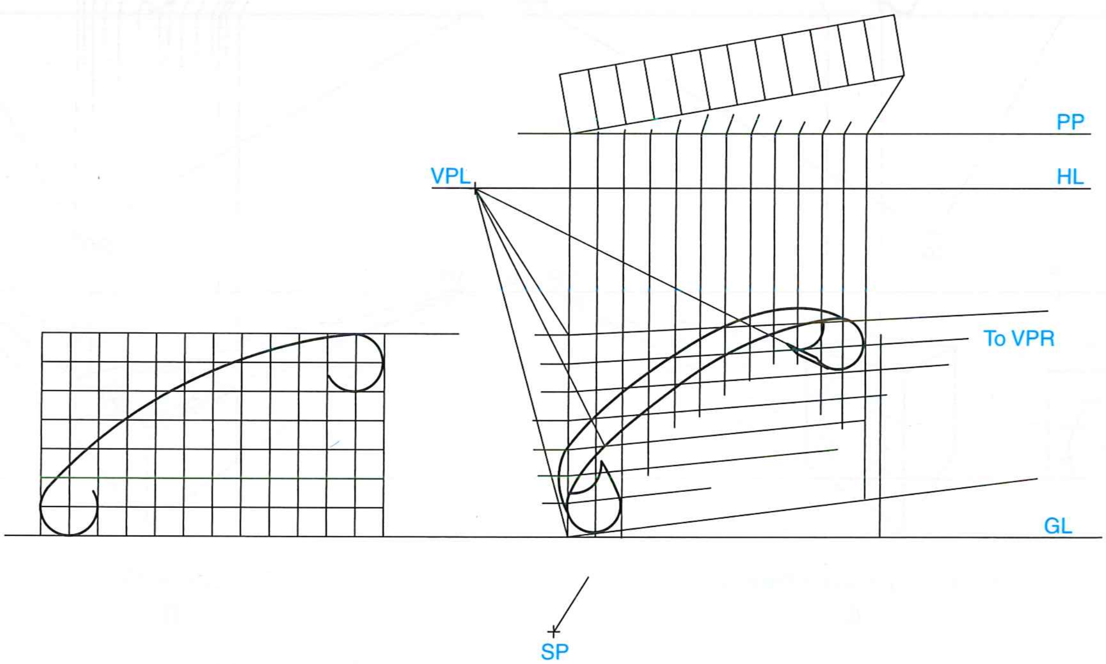


Figure 11-59. Irregular curves can be constructed in perspective views by using the coordinate method.

Perspective Drawing Boards

Special perspective drawing boards also speed the process of constructing perspective drawings. These boards are fairly simple to use and come with a variety of scales, permitting direct reading for layout of perspectives. Perspective boards are most valuable to drafters and illustrators who make frequent use of perspective drawings in their work.

Sketching in Perspective

The technique of sketching in perspective is based upon an understanding of the principles of sketching. Sketching principles and methods are discussed in Chapter 5. Also, the perspective projection methods discussed earlier in this chapter are applied to perspective sketches. Developing a technique for sketching in perspective is dependent on establishing accurate proportion of the objects being represented.

Sketch a Perspective Drawing

One-point and two-point perspective drawings can be sketched by constructing simple layouts and projecting lines to vanishing points. See **Figure 11-61**. The steps in sketching a two-point perspective are as follows.

1. Establish two vanishing points on the horizon line as far apart as desired, **Figure 11-61A**.
2. Sketch a true length (true scale) vertical line to represent the front corner of the object to be sketched. In **Figure 11-61A**, this feature has been centered between the two vanishing points and located below the horizon line. This positions the front faces of the object at 45° with the picture plane and orients a view from above the object.
3. Sketch lines from the ends of the front vertical line to the two vanishing points.
4. Sketch vertical lines at a distance of one-half the true distance (scale) from the front vertical line to establish the length of the two frontal planes.
5. From the upper-rear corners of these planes, sketch receding lines to the opposite vanishing points to form the top surface of the object.

Other features may be added to the sketch by measuring on the front corner and projecting to the proper location of depth on a half-scale basis. The object may be positioned so that its faces make angles of 30° and 60° with the picture plane by locating the front vertical line as shown in **Figure 11-61B**. Notice that the frontal planes are drawn to different scales. A sketching technique for a one-point perspective is shown in **Figure 11-61C**.

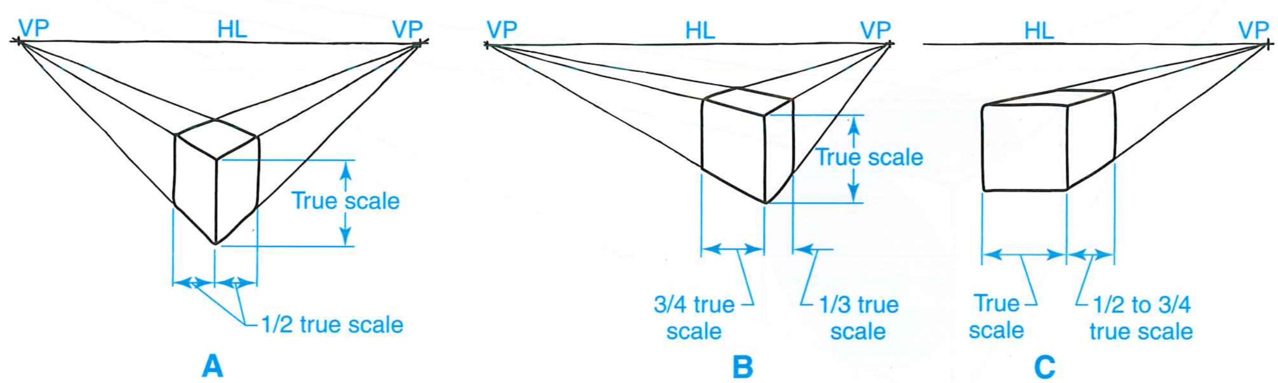


Figure 11-61. Sketching perspective drawings. A—A two-point perspective with the front faces of the object inclined at 45°. B—A two-point perspective with the front faces of the object inclined at 30° and 60°. C—A one-point perspective sketch.

Sketching Circles in Perspective Drawings

Circles are sketched as ellipses on perspective planes that are inclined to the picture plane. Circles oriented in this manner can be drawn by first drawing a circumscribing square, **Figure 11-62**. Then the center points of the sides of the square are located. The enclosed circle (ellipse) is then sketched.

CAD-Generated Models and Perspective Views

As previously discussed, CAD programs provide useful tools for creating and viewing three-dimensional drawings. Creating pictorial views with a CAD system greatly reduces the layout and drafting time required in manual drafting. Although it is possible to create 2D-based CAD pictorial drawings using the techniques discussed in this chapter, it is more common to use the 3D drawing functions of a CAD system to create true 3D models. After a model is created, viewing commands are used to display the desired 3D view. Depending on the program, pictorial views of models can be used to generate renderings. Renderings of pictorial views are commonly used to evaluate designs in various project phases.

CAD programs with modeling capability typically provide commands to create isometric and perspective views. As previously discussed, the **Orbit** command provides the most flexibility in establishing pictorial views. It allows you to rotate a model dynamically to set the desired viewing direction. The **Orbit** command is often used in conjunction with other viewing commands, such as the **View**, **Zoom**, and **Pan** commands. For example, you may first want to use the **View** command to establish an isometric view to view a model in 3D. After doing so, you can use the **Orbit** command to adjust the viewing angle so that a different pictorial is displayed.

In some programs, the **Orbit** command provides a **Perspective** option to display perspective views. Selecting this option changes the viewing angle from a parallel projection (where lines making up the pictorial planes of the object are parallel). See **Figure 11-63**. In perspective viewing mode, lines making up the pictorial planes recede to a vanishing point. Notice in **Figure 11-63** that the lines making up the object faces in the parallel projection remain parallel, while the lines making up the object faces in the perspective projection converge. This viewing option is a quick way to display perspective views for models such as buildings and other structures drawn in architectural drafting.

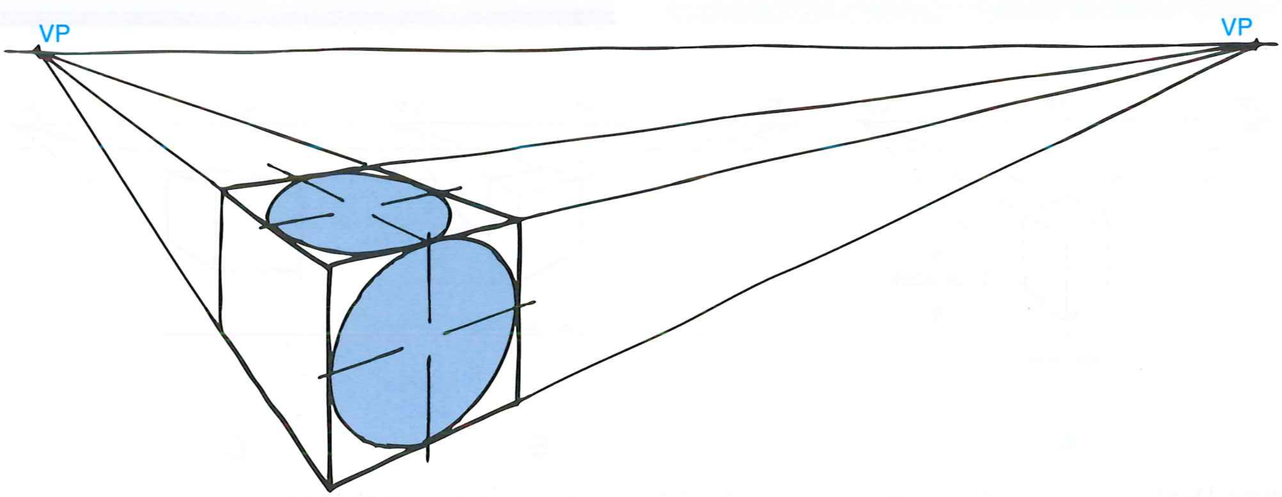
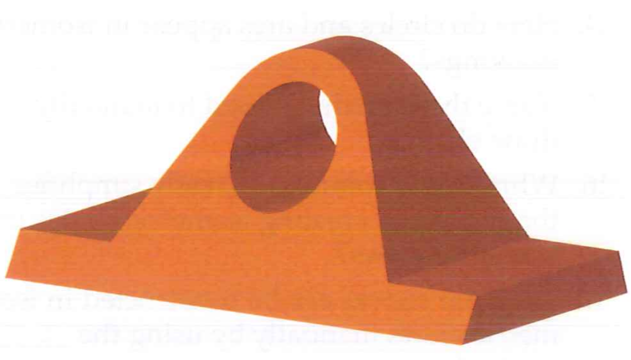


Figure 11-62. Circles in perspective are sketched by first sketching a circumscribing square and then locating perspective centerlines for the circle. Then the circle is sketched inside the square.



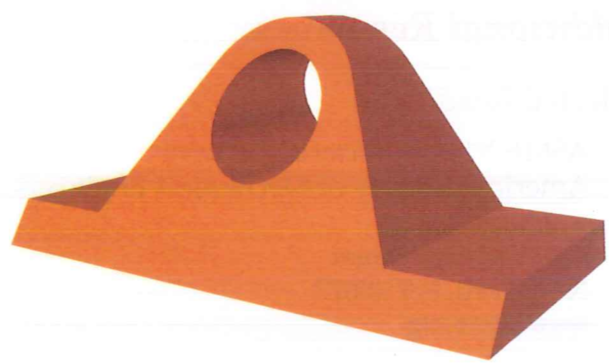


Figure 11-63. CAD programs provide viewing commands for creating different types of pictorial views. The **Perspective** option of the **Orbit** command is used to create perspective views. A—A parallel projection of a model. B—The same model displayed in perspective.

Chapter Summary

Pictorial drawings appear more "lifelike" than multiview drawings. These drawings are used to supplement multiview drawings or to substitute for multiviews. Pictorial drawings are widely used for assembly drawings, piping diagrams, service and repair manual illustrations, sales catalogs, and technical training manuals.

There are three basic types of pictorial projections in general use: axonometric, oblique, and perspective. In axonometric projection, the lines of sight are perpendicular to the plane of projection. There are three types of axonometric projections: isometric, dimetric, and trimetric. Isometric projection is the most popular of the three types. In an isometric projection, the three principal faces of a rectangular object are equally inclined to the plane of projection. Isometric angles, circles and arcs, irregular curves, and section views can be drawn using manual or CAD procedures. Pictorial drawing conventions determine how isometric drawings are dimensioned.

Dimetric and trimetric projection is similar to isometric projection. However, the principal faces are inclined at different angles to the plane of projection and are drawn differently.

Oblique projection is similar to axonometric projection. However, the lines of projection, though parallel to each other, intersect the plane of projection at an oblique angle. There are three types of oblique drawings: cavalier, cabinet, and general. The three differ only in the ratio of the scales used on the front axes and the receding axis. Arcs and circles located in the frontal plane of an oblique drawing appear in their true shape. Dimensioning oblique drawings is similar to isometric dimensioning.

Compared to other types of pictorial drawings, perspective drawings most nearly represent what is seen by the eye or camera. The three basic types of perspective drawings are one-point, two-point, and three-point. Each is named for the number of vanishing points used in the construction. Perspective drawing uses several unique terms that must be understood to produce a perspective. These include the terms station point, vanishing points, visual rays, picture plane, horizon line, and ground line.

A one-point perspective has only one vanishing point and the frontal plane of the object is parallel to the picture plane. This type of perspective is useful in representing the interior of objects.

In a two-point perspective, two sets of principal planes of the object are inclined to the picture plane. Parallel lines of the inclined sets converge at vanishing points on the horizon line. Two-point perspective drawing is useful in representing large structures.

Three-point perspectives add a third vanishing point. These drawings are generally used for large, tall structures.

CAD programs provide useful tools for creating 2D-based pictorials as well as 3D models and views. The 3D drawing functions of a CAD program allow the drafter to create true 3D models that can be displayed in different pictorial views. Models can be viewed from any angle and can appear very realistic when rendered.