7.1 AXONOMETRIC PROJECTION

The Greek word *axon* means axis and *metric* means to measure. **Axonometric projection** is a parallel projection technique used to create pictorial drawings of objects by rotating the object on an axis relative to a projection plane to create a pictorial view.

One of four principle projection techniques is used in technical drawing:

- Multiview
- Axonometric
- Oblique
- Perspective

In multiview, axonometric, and oblique projection the observer is theoretically infinitely far away from the projection plane. Only in perspective projection is the viewer at some finite distance to the object. The differences between a multiview drawing and an axonometric drawing are that, in a multiview, only two dimensions of an object are visible in each view and more than one view is required to define the object; whereas, in an axonometric drawing, the object is rotated about an axis to display all three dimensions, and only one view is required.

Axonometric drawings are classified by the angles between the lines comprising the axonometric axes. When all three angles are unequal the drawing is classified as a **trimetric**. When two of the three angles are equal the drawing is classified as a **dimetric**. When all three angles are equal the drawing is classified as a **isometric**.

Although there are an infinite number of positions that can be used to create such a drawing only are few are used.

7.2 ISOMETRIC AXONOMETRIC PROJECTIONS

An isometric view of an object is created by rotating it 45 degrees about a vertical axis, then tilted forward until the body diagonal of the cube (A-B) appears as a point in the front view. The angle the cube is titled forward is 35 degrees 16 minutes. The three corners meet to form equal angles of 120 degrees and is called the **isometric axis.** All the edges of the cube are parallel to the edges that make up the isometric axis since projections of parallel lines are parallel. Any line that is parallel to one of the legs of the isometric axis is called an **isometric line**. The planes of the faces of the cube and all planes parallel to them are called **isometric planes**.

The forward tilt of the cube causes the edges and planes of the cube to become foreshortened as it is projected onto the picture plane. Thus the projected lengths are approximately 80% of the true lengths and an isometric projection ruler must be used. If the drawing is drawn at full scale it is called an **isometric drawing**. Isometric drawings are almost always preferred over isometric projection for engineering drawings, because they are easier to produce.

The development of an isometric scale produced on paper using a regular scale.

Size comparison of isometric drawing and true isometric projection.

7.3 ISOMETRIC PICTORIAL SKETCHES

Isometric axes can be positioned in a number of different ways to create different views of the same object.

Regular isometric is developed looking down on the top of the object.

Reversed axis isometric is developed by looking up on the bottom of the object..

Long axis isometric is developed by looking from the right with one axis drawn at 60 degrees to the horizontal.

Any line that runs parallel to any of the isometric axes is called an **isometric line.** Any line that does not run parallel to an isometric axes is called a **non-isometric line.** Non-isometric lines are inclined and oblique object lines that cannot be measured directly when creating an isometric drawing but are must be created by locating two endpoints.

A cube represented in an isometric drawing. The three faces on the isometric cube are called isometric planes. **Isometric planes** are surfaces which are parallel to the isometric surfaces formed by any two adjacent isometric axes.

Planes which are not parallel to any isometric plane are called **non-isometric planes.**

In isometric drawings **hidden lines** are omitted unless absolutely necessary to completely describe the object. Normally, most isometric drawings will not have any hidden lines. You can avoid using hidden lines if the most descriptive viewpoint is chosen. However, there are times when the object has some features which cannot be described no matter which isometric viewpoint is taken.

In isometric drawings center lines are drawn if symmetry must be shown or for dimensioning. Normally, center lines are not used on isometric drawings.

Dimensioned isometric drawings used for production purposes must be ANSI standard, with dimension and extension lines and lines to be dimensioned lying in the same plane.

Dimensioned drawings used for illustration purposes may use the aligned method.

To draw an angle in an isometric drawing, locate the endpoints of the lines that form the angle and draw the lines between the endpoints..

Irregular curves are drawn in isometric by constructing points along the curve in the multiview drawing which are then located in the isometric view. These points are then connected with an irregular curve drawing instrument.

7.4 ISOMETRIC ELLIPSES

Isometric ellipses are a special type of ellipse used to represent holes and ends of cylinders in isometric drawings. In an isometric drawing, the object is viewed at an angle, which makes circles appear as ellipses.

Isometric assembly drawings used for production purposes normally have circles, called balloons, that contain numbers and are attached to leader lines, point to the various parts.

7.5 ISOMETRIC GRID PAPER

The use of isometric grid paper can improve your technique and decrease the time necessary to create an isometric sketch. Isometric grid paper is made of vertical and 30-degree grid lines

7.6 OBLIQUE PLANES IN ISOMETRIC VIEWS

The initial steps used to create an isometric sketch of an object with an oblique plane are the same as the steps used to create any isometric view. The sides of the oblique plane will be nonisometric lines, which means that their endpoints will be located by projections along isometric lines. After each endpoint is located, the oblique plane is drawn by connecting the endpoints.

7.7 ANGLES IN ISOMETRIC VIEWS

Angles can only be sketched true size when they are perpendicular to the line of sight. In isometric sketches, this is usually not possible; therefore, angles cannot be measured directly in isometric drawings.

7.8 IRREGULAR CURVES IN ISOMETRIC VIEWS

Irregular curves are sketched in isometric views by constructing points along the curve in the multiview drawing, locating those points in the isometric view, and then connecting the points by sketching or using a drawing instrument such as a French curve.

7.9 ISOMETRIC ELLIPSE TEMPLATES

Isometric ellipses can also be drawn using templates. Make sure the template is an isometric ellipse template, that is, one that has an *exposure angle of 35 degrees 16 minutes.*

7.10 SECTION VIEWS IN ISOMETRIC DRAWINGS

Section views are used to reveal the interior features of parts and structures. Isometric sketches of sections use isometric cutting planes to reveal interior features.

7.11 ISOMETRIC ASSEMBLY DRAWINGS

Isometric assembly drawings are classified as either assembled or exploded. Isometric assembly drawings used for production purposes normally have circles, called *balloons*, that contain numbers and are attached to leader lines pointing to the various parts.

7.12 OBLIQUE PROJECTIONS

Oblique drawings are a form of pictorial drawings in which the most descriptive or natural front view is placed parallel to the plane of projection.

Oblique projection is used as the basis for both oblique drawing and oblique sketching. However, oblique projection and to a large extent oblique drawing, is not as commonly used as other types of pictorials because of the excessive distortion that occurs. Because of its simplicity, many times oblique sketches are used to communicate ideas.

Oblique projection is a unique form of parallel projection. As the name indicates, oblique projection results when the projectors are parallel to each other but at some angle other than perpendicular to the projection plane. If the principal view of the object is placed such that its surfaces are parallel to the projection plane, the resulting projection is an oblique pictorial. Historically, the most descriptive face of an object in oblique projection has been placed parallel to the frontal plane.

The actual angles that the projectors make with the plane of projection in oblique projection is not significant, thus different angles can be used. However, angles for receding edges of between 30° and 60° are preferable because they offer minimum distortion of the object.

A comparison of orthographic projection and oblique projection.

Types of oblique drawings:

The **cavalier oblique** is drawn true length along the receding axis.

The **cabinet oblique** is drawn half the true length along the receding axis.

The **general oblique** can be drawn anywhere from full to half length along the receding axis.

The half-size receding axis on the cabinet oblique reduces the amount of distortion.

The various angles for a cavalier oblique drawing.

Any face of an object that is placed parallel to the frontal plane in oblique projection will be drawn true size and shape. Thus, the first rule in creating an oblique drawing is to develop the drawing so that cylinders or irregular surfaces are placed parallel to the frontal plane. This allows these features to be drawn quicker and without distortion.

A second rule in developing oblique drawings is that the longest dimension of an object should be located parallel to the frontal plane.

If there is conflict between these two rules always draw the cylindrical or irregular surfaces parallel with the frontal plane because representing this geometry without distortion is more advantageous.

Constructing an oblique sketch using the box technique.

7.13 OBLIQUE PICTORIAL SKETCHING

Oblique sketching attempts to combine the ease of sketching in two dimensions with the need to represent the third dimension. In an oblique sketch, the front face is seen in its true shape and is square with the paper, and only the depth axis is drawn at an angle. As with an isometric pictorial, the lines of projection are parallel to each other.

7.14 PERSPECTIVE PROJECTIONS

Perspective drawing techniques are used primarily because they come the closest to representing objects and scenes as we would view them in the real world. One of the most important features of perspective drawings is the **convergence** of parallel edges as they recede from the viewer.

Note that perspective drawing techniques were not developed until the 14th and 15th centuries in Europe. The earliest techniques, developed by artists such as Albrecht Durer, used projection frames to assist in the accurate recreation of what they saw with their eyes. Exercise 7.1 gives an example of how you can use clear plastic as a plane of projection and capture a perspective view.

7.15 PERSPECTIVE PROJECTION TERMINOLOGY

Terminology will be important for both explaining perspective drawing techniques and laying them out. Important terms include:

The **horizon line** is the position that represents the eye level of the observer.

The **station point** in the perspective drawing is the eye of the observer.

The **picture plane** is the plane upon which the object is projected.

A **vanishing point** is the position on the horizon where lines of projection converge.

The **ground line** represents the plane on which the object rests.

Changing the object's position relative to the picture plane determines the size of the object.

Changing the vertical alignment of the alignment of the vanishing point an the object controls the direction of the lines of convergence.

Tracing the line of convergence in a photograph or rendered image can be used to find the vanishing point.

The figure demonstrates how the relationship between the horizon line (**HL**) and ground line (**GL**) determines the type of perspective view:

Bird's eye view: ground line below the horizon line.

Human's eye view: ground line six feet below the horizon line.

Ground's eye view: ground line at the same level as the horizon line.

Worm's eye view: ground line above the horizon line.

7.16 PERSPECTIVE PROJECTION CLASSIFICATIONS

Perspective views are classified according to the number of **vanishing points**. Increasing the number of vanishing points increases the realism of the drawing but also increases the drawing difficulty. The vanishing points for a one- and two-point perspective drawings both go to the horizon line. The third vanishing point in a three-point perspective drawing is located perpendicular to the horizon line.

7.17 PERSPECTIVE PROJECTION VARIABLES SELECTION

Emphasize the importance of planning ahead for a drawing by deciding on a number of key variables. Since the primary purpose of a perspective drawing is to convey a sense of realism, it is important to define the relationship of the observer to the object. The important variables are:

Distance of the *object* from the *picture plane*

Position for the *station point*

Position of the *ground line* relative to the *horizon line*

Number of *vanishing points*

For example, the depiction of a toaster would probably have the object fairly close to the picture plane with the observer looking either straight ahead or slightly down at it (i.e.

human's eye or bird's eye view). On the other hand, a large building would be farther away using either a worm's eye or ground's eye view, depending on how far the building is from the observer.

7.18 CAD PERSPECTIVE DRAWINGS

As 3-D CAD becomes more popular, perspective pictorials drawn by hand will largely be replaced by ones created from the model on computer. Where hand—constructed perspective pictorials will still be applicable is when a pictorial sketch needs to depict some convergence — usually a larger object such as a building.

Just as with a hand-drawn perspective, defining the relationship between the viewer and the object is critical to a the creation of a successful pictorial. With most 3-D CAD systems, a viewpoint can be established anywhere with any cone of vision. The key is to set these variables so that the necessary geometric information is most clearly communicated to the viewer.

7.19 SUMMARY

The three classifications of pictorial projections are axonometric, oblique, and perspective. Isometric sketches are the most popular among the various axonometric drawings, because they are the easiest to create. Both axonometric and oblique projections use parallel projection. As the axis angles and view locations are varied, different pictorial views of an object can be produced.

Perspective sketches use converging lines to produce a pictorial view. The converging lines recede to vanishing points which produce a realistic looking image. Perspectives are commonly used in architectural work to create realistic scenes of buildings and structures. In this chapter you learned there are three types of perspective projections: one-, two-, and three-point. Each type refers to the number of vanishing points used in the construction of the drawings. Other variables, such as position of the ground line in relation to the horizon line, can be controlled to produce virtually any view of an object.