CHAPTER 7 Pictorial Projections

OBJECTIVES

After completing this chapter, the student will be able to:

1. Define axonometric, isometric, dimetric, and trimetric projection.
2. Explain the difference between an isometric projection and an isometric sketch.
3. Create an isometric sketch.
4. Apply the theory of oblique projection to create oblique sketches.
5. Create a one-point perspective sketch.
6. Describe one-, two-, and three-point projection theory.
7. Define horizon line, station point, picture plane, vanishing point, and ground line.
8. Describe and draw bird's eye, human's eye, ground's eye, and worm's eye views.
9. Describe the four perspective variables that are determined before creating a perspective sketch.

INTRODUCTION

Pictorial sketches are a type of technical illustration that shows several faces of an object at once. Such sketches are used by any industry that designs, sells, manufactures repairs, installs or maintains a product. Axonometric and oblique pictorial sketches use a parallel projection technique and are frequently used in technical documents, sales literature, maintenance manuals, and documentation supplements in engineering drawings.

Perspective sketches are the most realistic types of drawings used in engineering and technology. A perspective drawing creates a pictorial view of an object that resembles what you see. It is the best method for representing an object in three dimensions.

This chapter goes into the details necessary for creating perspective sketches.

AXONOMETRIC PROJECTION

7.1 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.

7.2 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.

7.3 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 an isometric.

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

**ISOMETRIC AXONOMETRIC PROJECTIONS**

7.5 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 tilted 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.

7.6 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.

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

7.8 Size comparison of isometric drawing and true isometric projection.

**ISOMETRIC AXONOMETRIC DRAWINGS**

7.9 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.

7.10 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.
7.11 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.

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

7.13 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.

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

7.15 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.

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

7.17 Creating a isometric drawing.

7.18 Circles that lie on any face of an isometric cube will appear as ellipses.

7.19 Sketching an isometric ellipse.

7.20 Sketching an isometric cylinder.

7.21 Since arcs are partial circles, they appear in isometric drawings as partial isometric ellipses.

7.22 Isometric sketches of common objects.

7.23 Constructing an isometric sketch having an oblique surface.

7.24 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.

7.25 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.

7.26-7 Drawing isometric ellipses using an isometric ellipse template. Make sure that the template is a true isometric template. That is, it has an exposure angle of 35 degrees 16 minutes.

7.28-30 Section views in isometric sketches.

7.31 3-D models projected as an isometric drawing.

7.32 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.

**OBLIQUE PROJECTION AND SKETCHING**

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.

**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.

**PERSPECTIVE PROJECTION TERMINOLOGY**

7.48 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.

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

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

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

7.52 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.

**PERSPECTIVE PROJECTION CLASSIFICATIONS**

7.53 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.

**PERSPECTIVE PROJECTION VARIABLES SELECTION**

7.54 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.

CAD PERSPECTIVE DRAWINGS

7.55-7 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 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.

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.

GOALS REVIEW

1. Define axonometric, isometric, dimetric, and trimetric projection. Section 7.1

2. Explain the difference between an isometric projection and an isometric sketch. Section 7.2

3. Create an isometric sketch. Section 7.3

4. Apply the theory of oblique projection to create oblique sketches. Section 7.12

5. Create a one-point perspective sketch. Section 7.19

6. Describe one-, two-, and three-point projection theory. Section 7.16

7. Define horizon line, station point, picture plane, vanishing point, and ground line. Section 7.15
8. Describe and draw bird's eye, human's eye, ground's eye, and worm's eye views. Section 7.15

9. Describe the four perspective variables that are determined before creating a perspective sketch. Section 7.17

QUESTIONS FOR REVIEW

1. Define oblique projection.

2. List and describe the differences between the three different types of oblique drawing.

3. Define axonometric.

4. Define isometric, dimetric, and trimetric drawings.

5. Sketch the axes used for an isometric drawing.

6. Sketch the axes used for regular, reversed, and long axis isometric drawings.

7. What is the general rule used for hidden lines in isometric drawings?

8. Give examples of pictorial drawings are used in industry.

9. Sketch an isometric cube then show how isometric ellipses would be drawn on each face of the cube. Add center lines to the ellipses.

10. What are the three angular measurements of an isometric drawing axes?

11. Describe perspective projection theory. Use sketches if necessary.

TRUE AND FALSE QUESTIONS

1. In sketching an ellipse to represent a circle pictorially, an enclosing “isometric square” (rhombus) is drawn having sides equal approximately to the radius of the true circle.

2. An isometric drawing of a figure is slightly larger than the isometric projection.

3. An isometric drawing and an isometric projection are one in the same.

4. In isometric drawing, lines that are parallel to the isometric axes are called isometric lines.

5. In isometric drawing, lines that are not parallel to the isometric axes are called nonisometric lines.

6. Long axis isometric drawings are drawn with one of the axes 60° to the horizontal.

7. Aligned isometric dimensioning is used for isometric production drawings.

8. Hidden lines, unless absolutely necessary for clarity, always should be omitted on an isometric drawing.

9. The angles of an inclined line in a orthographic view can be transferred directly to an isometric drawing.

10. An oblique drawing is drawn with features in two of the dimensions shown in true size and shape.
11. A cabinet oblique is drawn true length along the receding axis.

12. A perspective pictorial drawing is less realistic but easier to draw than an isometric pictorial.

13. Unlike an isometric pictorial, a perspective pictorial drawing does not represent parallel edges in depth as parallel.

14. Examples of perspective drawings have been found on prehistoric cave wall paintings.

15. Perspective drawings can be created that represent locations of the viewer relative to the object which vary both right and left and up and down.

MULTIPLE CHOICE QUESTIONS

1. If a client of yours is having difficulty visualizing a design, what type of drawing would be the easiest to understand?
   a. axonometric
   b. three-view orthographic
   c. one-view orthographic
   d. bimetric

2. Which of the following is not a pictorial drawing?
   a. isometric
   b. multiview
   c. perspective
   d. axonometric

3. Which of the following projection methods does not use projectors perpendicular to the projection plane?
   a. isometric
   b. orthographic
   c. oblique
   d. axonometric
4. A circle will appear on an isometric drawing as a(n) __________.
   a. ellipse
   b. cycloid
   c. circle
   d. parabola

5. An axonometric drawing which has two axes divided by equal angles is:
   a. dimetric
   b. trimetric
   c. orthographic
   d. isometric

6. An axonometric drawing which has all three axes divided by equal angles is:
   a. dimetric
   b. trimetric
   c. orthographic
   d. isometric

7. In a trimetric drawing, the relationship of the angle between axes to each other is:
   a. three are equal
   b. two are equal
   c. three are unequal
   d. none of the above

8. In an isometric sketch of a cube:
   a. the frontal face appears in its true shape
   b. the receding axes are at 45 degrees to the horizontal
   c. all faces are equally distorted
   d. only the depth distances must be reduced

9. In isometric drawings:
   a. Two axes are perpendicular
   b. True measurements can be made only along or parallel to the isometric axes
   c. All faces are unequally distorted
   d. None of the above

10. In an axonometric drawing, the projection rays are drawn ________ to each other and _______ to
    the plane of projection.
    a. parallel.....oblique
    b. oblique.....parallel
    c. parallel.....perpendicular
    d. parallel....parallel

11. Non-isometric lines are located and sketched how?
    a. They are drawn parallel to the isometric axis.
    b. They are measured using the angle from the multiview.
    c. They are measured using a non-isometric template.
    d. They are located by determining the endpoints of the non-isometric line.
12. In an oblique sketch of a cube:
   a. the frontal face appears in its true shape
   b. both receding axes are at 30 degrees to the horizontal
   c. all faces are equally distorted
   d. the depth distances must be reduced

13. In an oblique drawing, all of the following angles are commonly used for drawing the depth axis, except:
   a. 30°
   b. 45°
   c. 60°
   d. 90°

14. In an oblique drawing, the projection rays are drawn _________ to each other and _______ to the plane of projection.
   a. oblique.....oblique
   b. oblique.....parallel
   c. parallel.....oblique
   d. parallel....parallel

15. Which type of perspective view represents an adult viewer looking at an object on a high kitchen shelf?
   a. bird's eye view
   b. worm's eye view
   c. human's eye view
   d. ground's eye view

16. Which type of perspective view represents an adult viewer looking at an object on the ground?
   a. bird's eye view
   b. worm's eye view
   c. human's eye view
   d. ground's eye view

17. In a perspective drawing, the object always touches the:
   a. ground line
   b. horizon line
   c. measuring line
   d. station point