Intersections

Learning Objectives

After studying this chapter, you will be able to:

- List the basic types of geometric surfaces and intersections.
- Describe how intersections are formed and identify the common methods used in their construction.
- Construct intersections using manual and CAD procedures.
- List the applications of intersections in construction and manufacturing.

Technical Terms

Auxiliary view method
Cutting plane method
Double-curve geometrical surfaces
Intersecting lines
Intersection
Orthographic projection method
Piercing point
Plane surfaces
Ruled geometrical surfaces
Single-curve surfaces
Warped surfaces

When two objects join or pass through each other, the line formed at the junction of their surfaces is known as an ***intersection***. Intersecting objects may include plane surface intersections or different types of surface intersections. For example, certain combinations of objects (such as a square prism and a cylinder) include an intersection between a plane surface and a curved surface.

Numerous examples of intersections can be found in industry. Frequently, building designs require architects and engineers to define the intersections of surfaces. The aerospace and automotive industries also work with intersections of various shapes in the manufacture of instrument panels, body sections, window openings, wings, and fuselages. See **Figure 14-1**.

This chapter covers the basic geometric forms of intersecting objects and the principles used in constructing intersections. Once these principles and the techniques of their application are understood, most intersection problems can be solved.

Figure 14-1. Defining the intersections of surfaces, such as those used in the design of automobile body panels, requires careful study and planning for proper assembly.

Types of Intersections

Intersections and their solutions are classified on the basis of the types of geometrical surfaces involved. Two broad classifications of geometrical surfaces are ruled geometrical surfaces and double-curve geometrical surfaces.

Ruled Geometrical Surfaces

Ruled geometrical surfaces are surfaces generated by moving a straight line. They may be subdivided into ***plane surfaces, single-curve surfaces,*** and ***warped surfaces,*** **Figure 14-2**.

Plane surfaces and single-curve surfaces can be developed. If a surface can be developed, it can be "unfolded" or "unrolled" into a single plane.

Warped surfaces cannot be developed into a single plane. Usually, these surfaces are formed to true shape by peening, stamping, spinning, or by a vacuum or explosive process, **Figure 14-3**. Warped surfaces can be divided into sections and developed. However, this sectioning produces only an approximation of the true warped surface.

Double-Curve Geometrical Surfaces

Double-curve geometrical surfaces are surfaces generated by a curved line revolving around a straight line in the plane of the curve, **Figure 14-4**. Double-curve surfaces, like warped surfaces, cannot be developed into single-plane surfaces. However, the "gore method" can be used to approximate the development of a spherical surface, **Figure 14-5**.

Spatial Relationships

In Chapter 8 of this text, an introduction to normal points, normal lines, and normal surfaces in space was given. In Chapter 12, you learned techniques for locating inclined and oblique lines and surfaces in space. There are a few additional basic spatial relationships that must be understood before you can solve problems of intersection and development. These are discussed in the following sections.

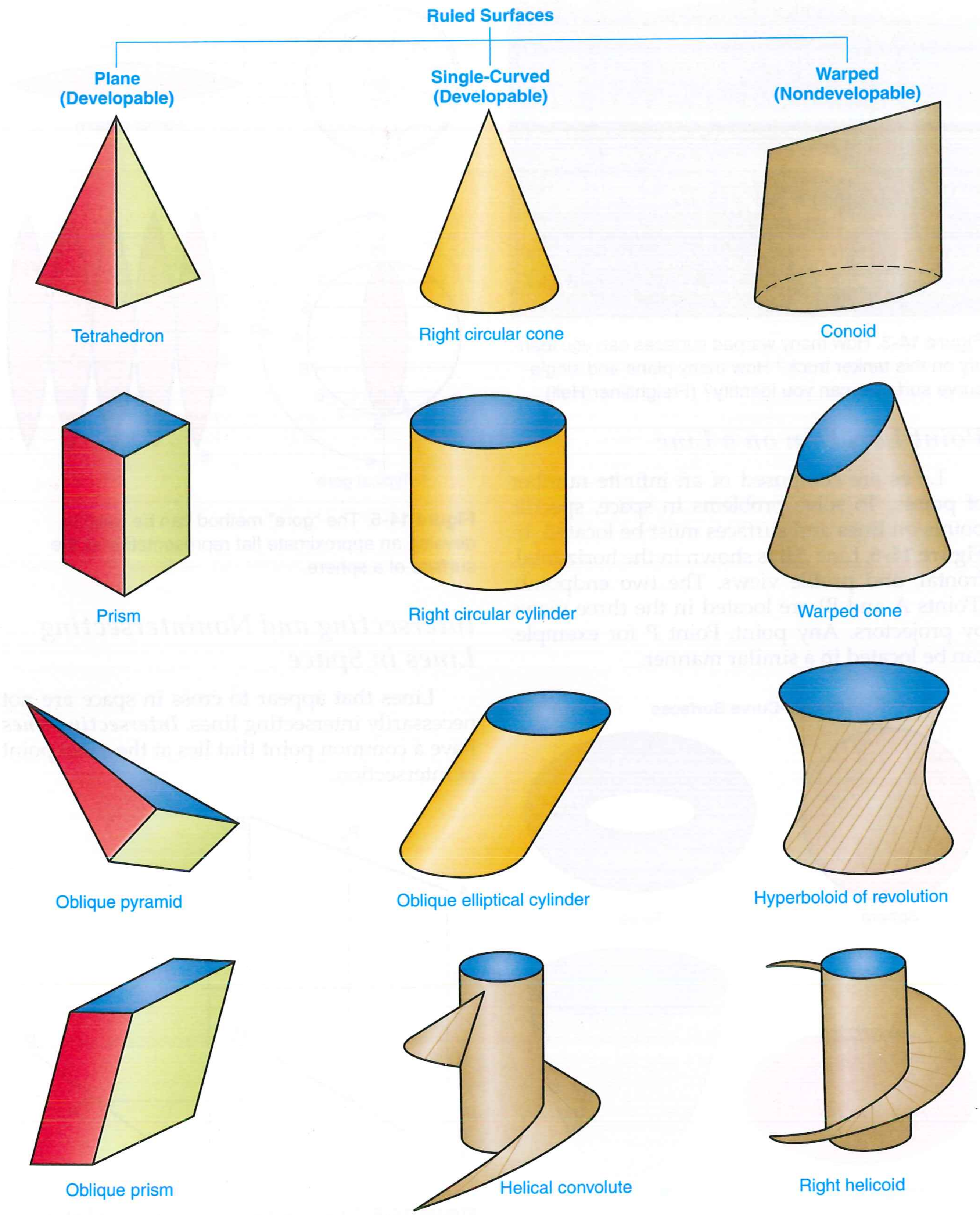

Figure 14-2. There are three types of ruled geometrical surfaces: plane, single-curve, and warped. Plane and single-curve surfaces can be developed, but warped surfaces cannot.

Figure 14-3. How many warped surfaces can you identify on this tanker truck? How many plane and single-curve surfaces can you identify? (Freightliner/Heil)

Point Location on a Line

Lines are composed of an infinite number of points. To solve problems in space, specific points on lines and surfaces must be located. In **Figure 14-6**, Line AB is shown in the horizontal, frontal, and profile views. The two endpoints (Points A and B) are located in the three views by projectors. Any point, Point P for example, can be located in a similar manner.

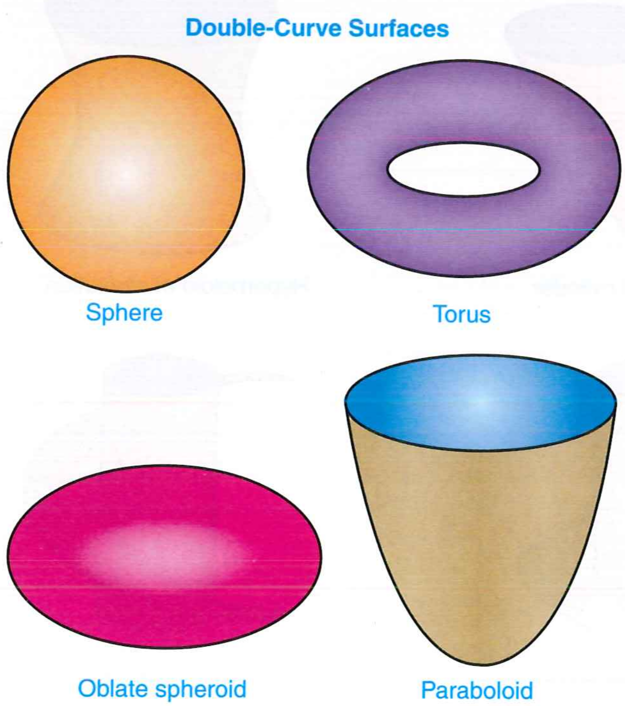

Figure 14-4. Double-curve geometrical surfaces are formed by a curved line revolving around a straight line that is in the plane of the curve.

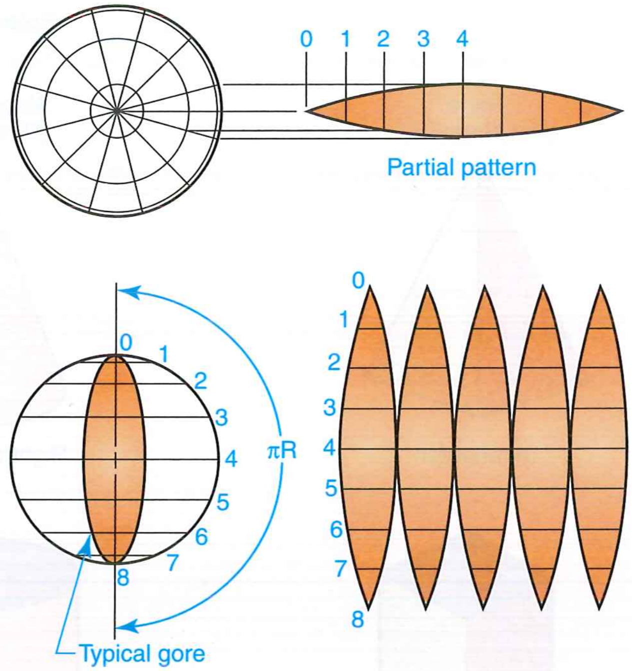

Figure 14-5. The "gore" method can be used to develop an approximate flat representation of the surface of a sphere.

Intersecting and Nonintersecting Lines in Space

Lines that appear to cross in space are not necessarily intersecting lines. ***Intersecting lines*** have a common point that lies at the exact point of intersection.

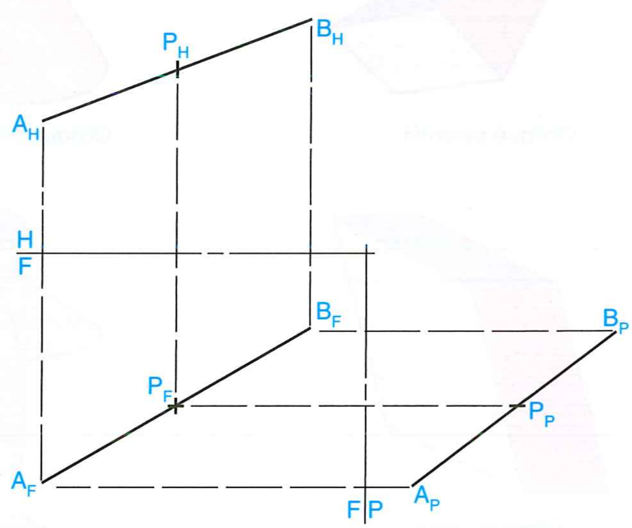

Figure 14-6. Lines consist of an infinite number of points. Any point on a line can be located in the frontal (F), horizontal (H), or profile (P) planes by using perpendicular projectors.

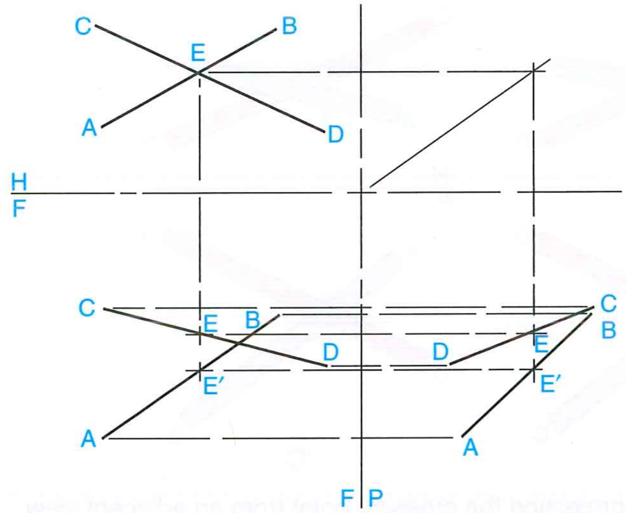

Figure 14-7. Lines AB and CD appear to cross in the horizontal plane. However, when Point E is projected to the frontal and profile planes, it is clear that Point E is not common to both lines. Therefore, the lines do not intersect.

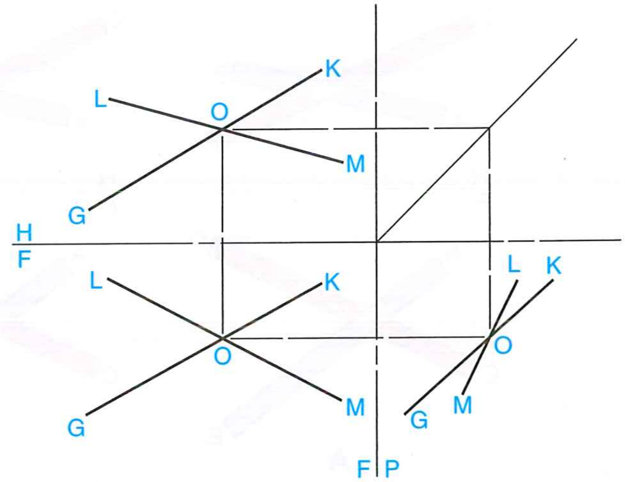

Figure 14-8. Lines GK and LM appear to intersect in the horizontal plane. When Point O is projected to both the frontal and profile planes, it is clear that Point 0 is common to both lines. Therefore, the lines do intersect.

As shown in **Figure 14-7**, two lines (Lines AB and CD) appear to intersect in the horizontal view. However, in order to intersect, they must have a point common to both lines. In the example shown, Point E is located in the horizontal view and projected to intersect Lines AB and CD in the front view. It is apparent in the front view that Point E is not a single point common to both lines. Therefore, the lines do not intersect. This is further shown in the right side, or profile, view.

In **Figure 14-8**, Lines GK and LM *do* intersect. They have a common point that lies on both lines. This is revealed by orthographic projection. Two views are sufficient to determine whether crossing lines are intersecting lines. Note that Point O is common to both lines in any two views, verifying the intersection of the lines.

Visibility of Crossing Lines in Space

The visibility of crossing lines is established by projecting the crossing point of the lines from an adjacent view, **Figure 14-9**. As shown in **Figure 14-9A**, Lines AB and CD are crossing lines (but do not intersect). To determine the visible line at the crossing point in the top view, project the crossing point from the top view, **Figure 14-9B**. The projection line "touches" Line CD "first" in the front view. This indicates that Line CD is "higher." Therefore, Line CD is visible in the top view at the point of crossing.

To determine the visible line in the front view, project the point of crossing from the front view, **Figure 14-9C**. The projector "touches" Line AB first. This indicates that Line AB is closer to the frontal viewing plane. Therefore, Line AB is visible at the crossing point of the two lines.

Visibility of a Line and a Plane in Space

Determining the visibility of a line and a plane that cross in space is similar to the procedure for two crossing lines. As shown in **Figure 14-10**, Line AB and Plane CDE cross in the horizontal and front views. Line AB crosses two "edges" of the plane, **Figure 14-10A**. Lines CE and ED represent two edges of the plane, and Line AB crosses these two lines.

The visibility in the horizontal view is determined by projecting the crossing points to the front view, **Figure 14-10B**. The projectors "touch" Line AB before they "touch" the plane. This indicates that the line is "higher" than the plane at these points and, therefore, visible in the horizontal view.

Since the projectors "touch" the plane before the line in the top view, as shown in **Figure 14-10C**, Line AB is invisible in the front view. This indicates that Plane CDE is closer to the frontal plane and that Line AB crosses "behind" Plane CDE.

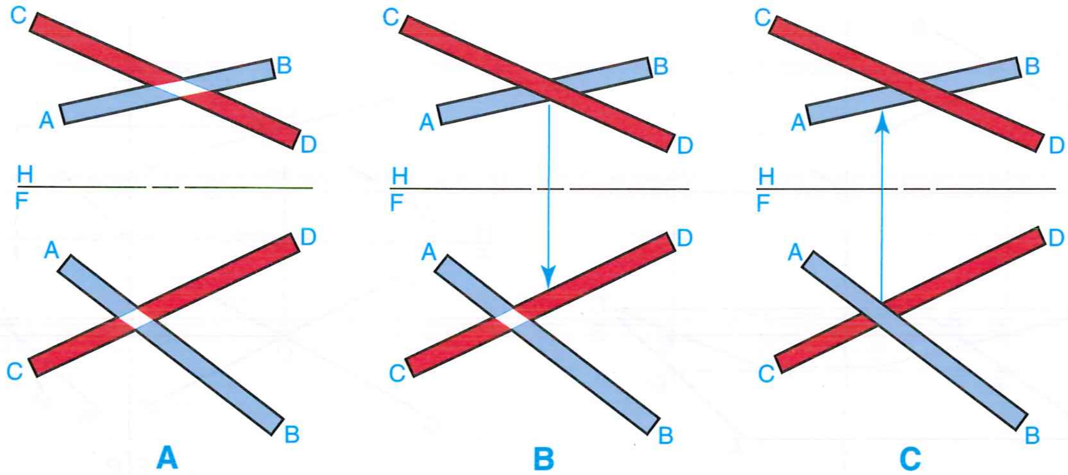

Figure 14-9. The visibility of crossing lines is determined by projecting the crossing point from an adjacent view. A—Lines AB and CD are crossing lines. B—When the crossing point is projected from the top view, Line CD is "touched" first. Therefore, Line CD is visible in the top view at the crossing point. C—When the crossing point is projected from the front view, Line AB is "touched" first. Therefore, in the front view, Line AB is visible at the crossing point.

Triangular planes have been used here and are used in other sections to illustrate the intersection of lines and surfaces. Triangular planes and triangular prisms make understanding the principles and procedures less complex. The general procedure described for the intersection of planes, given later in this chapter, is the same regardless of the number of edges a plane has.

Location of the Piercing Point of a Line with a Plane (Orthographic Projection Method)

The point of intersection between a plane and a line inclined to that plane is called the *piercing point*. The location of the piercing point is essential to the solution of many technical

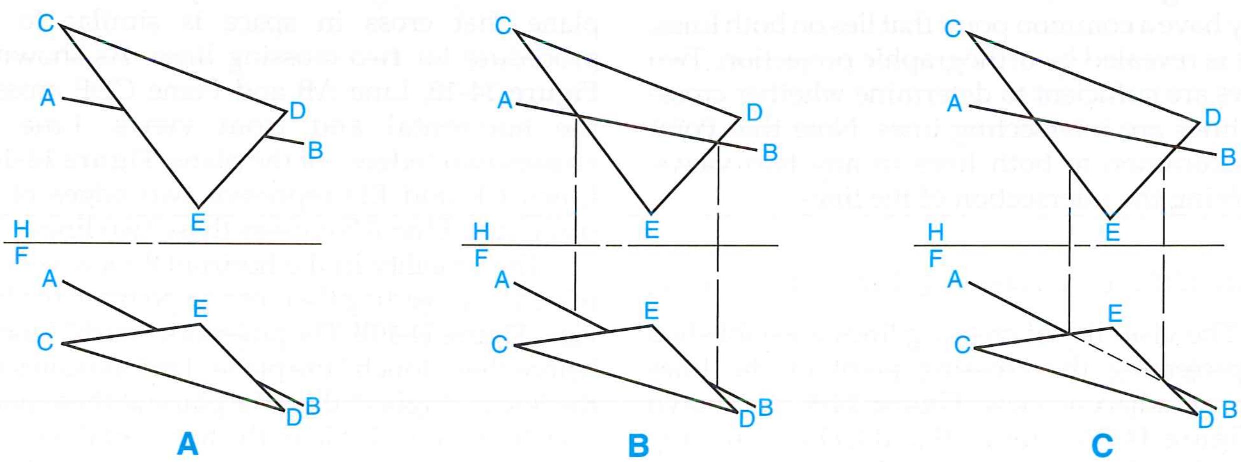

Figure 14-10. The visibility of a line crossing a plane is determined by projecting the crossing points of the line with the "edge" of the plane from an adjacent view. A—Line AB crosses Plane CDE in the top and front views. B—If the crossing points are projected from the top view, the line is "touched" first. Therefore, the line is "above" the plane in the top view. C—If the crossing points are projected from the front view, the plane is "touched" first. Therefore, the line is "below" the plane in the front view.

problems. The intersection of pipes and tubing with valves and cylinders requires the location of piercing points, **Figure 14-11**.

Given the top and front views of a line and a plane, use the following procedure to locate the piercing point of a line and a plane. See **Figure 14-12**. If you are drawing manually, use manual projection techniques. If you are using a CAD system, draw construction lines using the **Xline** command. Use Ortho mode and object snaps as needed.

1. Draw a vertical cutting plane through the top view of Line AB (see the pictorial view in **Figure 14-12**) that intersects Plane DCE at Points G and K, **Figure 14-12B**.
2. Project Points G and K to the front view.
3. The intersection of the imaginary cutting plane and Plane CDE is represented by the trace line (Line GK) in the front view, **Figure 14-12C**.

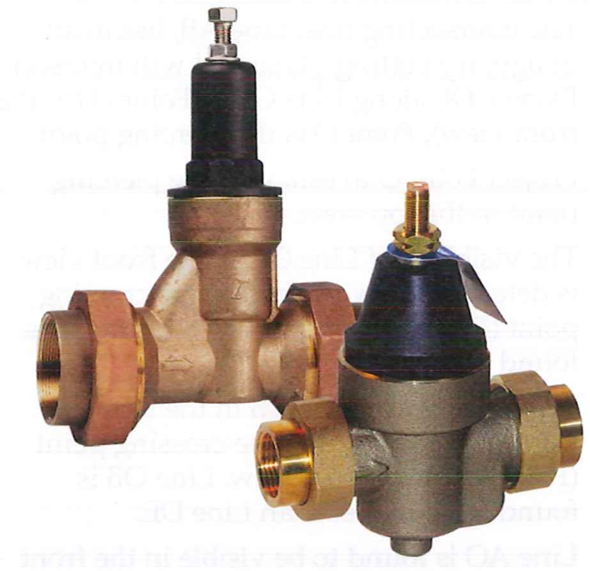

Figure 14-11. The locations of piercing points of lines and planes is necessary in the design of valve assemblies. Can you identify the locations of piercing points for these valves? (Watts Regulator Co.)

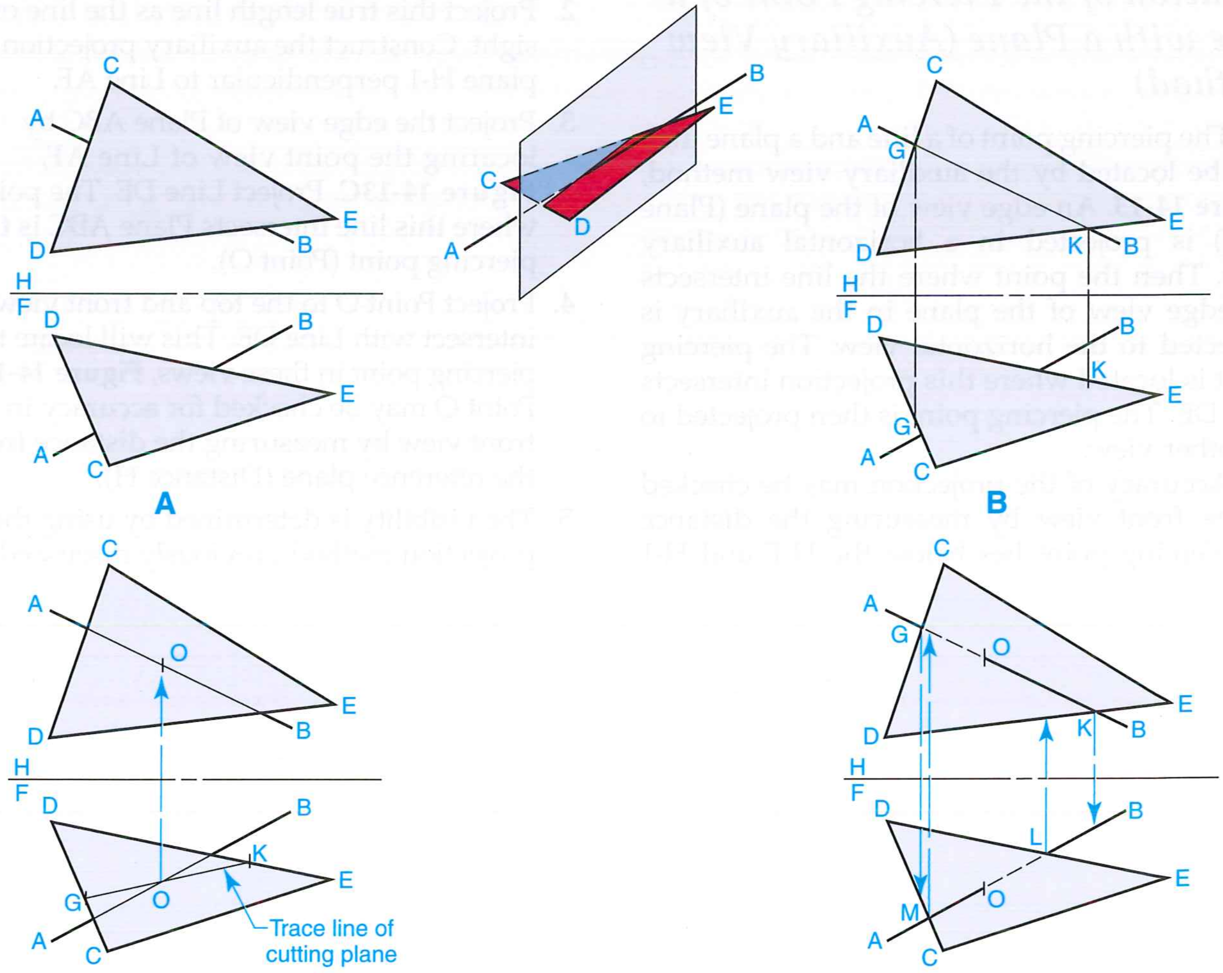

Figure 14-12. The orthographic projection method can be used to find the piercing point of a line with a plane.

4. The intersecting line, Line AB, lies in an imaginary cutting plane and will intersect Plane CDE along Line GK at Point O (in the front view). Point O is the piercing point.
5. Project Point O to establish the piercing point in the top view.
6. The visibility of Line OB in the front view is determined by projecting the crossing point (Point L) to the top view. Line OB is found to be behind Line DE.
7. The visibility of Line OB in the top view is found by projecting the crossing point (Point K) to the front view. Line OB is found to be higher than Line DE.
8. Line AO is found to be visible in the front view and invisible in the top view by projecting the crossing points (Points M and G).

Location of the Piercing Point of a Line with a Plane (Auxiliary View Method)

The piercing point of a line and a plane may also be located by the auxiliary view method, **Figure 14-13**. An edge view of the plane (Plane ABC) is projected in a horizontal auxiliary view. Then the point where the line intersects the edge view of the plane in the auxiliary is projected to the horizontal view. The piercing point is located where this projection intersects Line DE. The piercing point is then projected to the other view.

Accuracy of the projection may be checked in the front view by measuring the distance the piercing point lies below the H-F and H-1 projection planes. Refer to **Figure 14-13**. The visibility of the line and plane is found by determining whether the line or the plane lies closer to the projection plane in the adjacent view at the crossing point. The closer of the two objects is visible.

Given the top and front views of Plane ABC and the line that intersects the plane, Line DE, use the following procedure to locate the piercing point and the visibility of the line and plane. If you are drawing manually, use manual projection techniques. If you are using a CAD system, draw construction lines using the **Xline** command. Use the **Offset** command to create the auxiliary view and use calculated distances to project points between views. Use object snaps as needed.

1. Draw a horizontal line (Line AF) in the front view. Project this line to the top view to produce a true length line, **Figure 14-13B**.
2. Project this true length line as the line of sight. Construct the auxiliary projection plane H-1 perpendicular to Line AF.
3. Project the edge view of Plane ABC by locating the point view of Line AF, **Figure 14-13C**. Project Line DE. The point where this line intersects Plane ABC is the piercing point (Point O).
4. Project Point O to the top and front views to intersect with Line DE. This will locate the piercing point in these views, **Figure 14-13D**. Point O may be checked for accuracy in the front view by measuring the distance from the reference plane (Distance H).
5. The visibility is determined by using the projection method previously discussed.

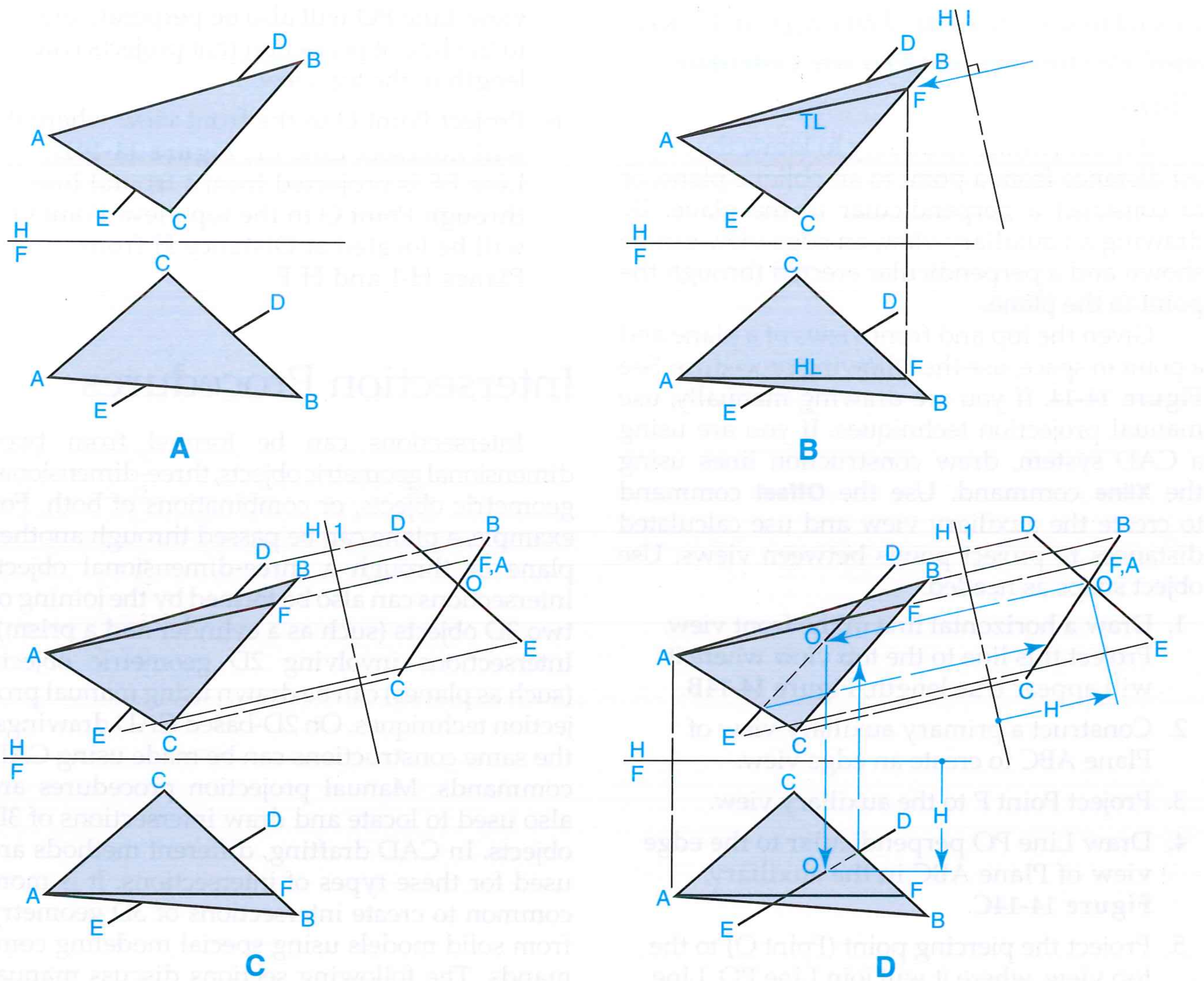

Figure 14-13. The auxiliary view method can be used to locate the piercing point of a line with a plane.

Location of a Line Through a Point and Perpendicular to an Oblique Plane

It is sometimes necessary to locate the shortest distance from a point to an oblique plane, or to construct a perpendicular to the plane. By drawing an auxiliary view, an edge view can be shown and a perpendicular erected through the point to the plane.

Given the top and front views of a plane and a point in space, use the following procedure. See **Figure 14-14**. If you are drawing manually, use manual projection techniques. If you are using a CAD system, draw construction lines using the **Xline** command. Use the **Offset** command to create the auxiliary view and use calculated distances to project points between views. Use object snaps as needed.

1. Draw a horizontal line in the front view. Project this line to the top view where it will appear true length, **Figure 14-14B**.
2. Construct a primary auxiliary view of Plane ABC to create an edge view.
3. Project Point P to the auxiliary view.
4. Draw Line PO perpendicular to the edge view of Plane ABC in the auxiliary, **Figure 14-14C**.
5. Project the piercing point (Point O) to the top view, where it will join Line PO. Line PO is parallel to the projection plane H-1 since it is a true length line in the auxiliary view. Line PO will also be perpendicular to the line of projection that projects true length in the top view.
6. Project Point O to the front view where it will intersect Line EF, **Figure 14-14D**. Line EF is projected from a frontal line through Point O in the top view. Point O will be located at Distance H from Planes H-1 and H-F.

Intersection Procedures

Intersections can be formed from two-dimensional geometric objects, three-dimensional geometric objects, or combinations of both. For example, a plane can be passed through another plane or through a three-dimensional object. Intersections can also be formed by the joining of two 3D objects (such as a cylinder and a prism). Intersections involving 2D geometric objects (such as planes) can be drawn using manual projection techniques. On 2D-based CAD drawings, the same constructions can be made using CAD commands. Manual projection procedures are also used to locate and draw intersections of 3D objects. In CAD drafting, different methods are used for these types of intersections. It is more common to create intersections of 3D geometry from solid models using special modeling commands. The following sections discuss manual and CAD drawing procedures for intersections of geometric objects.

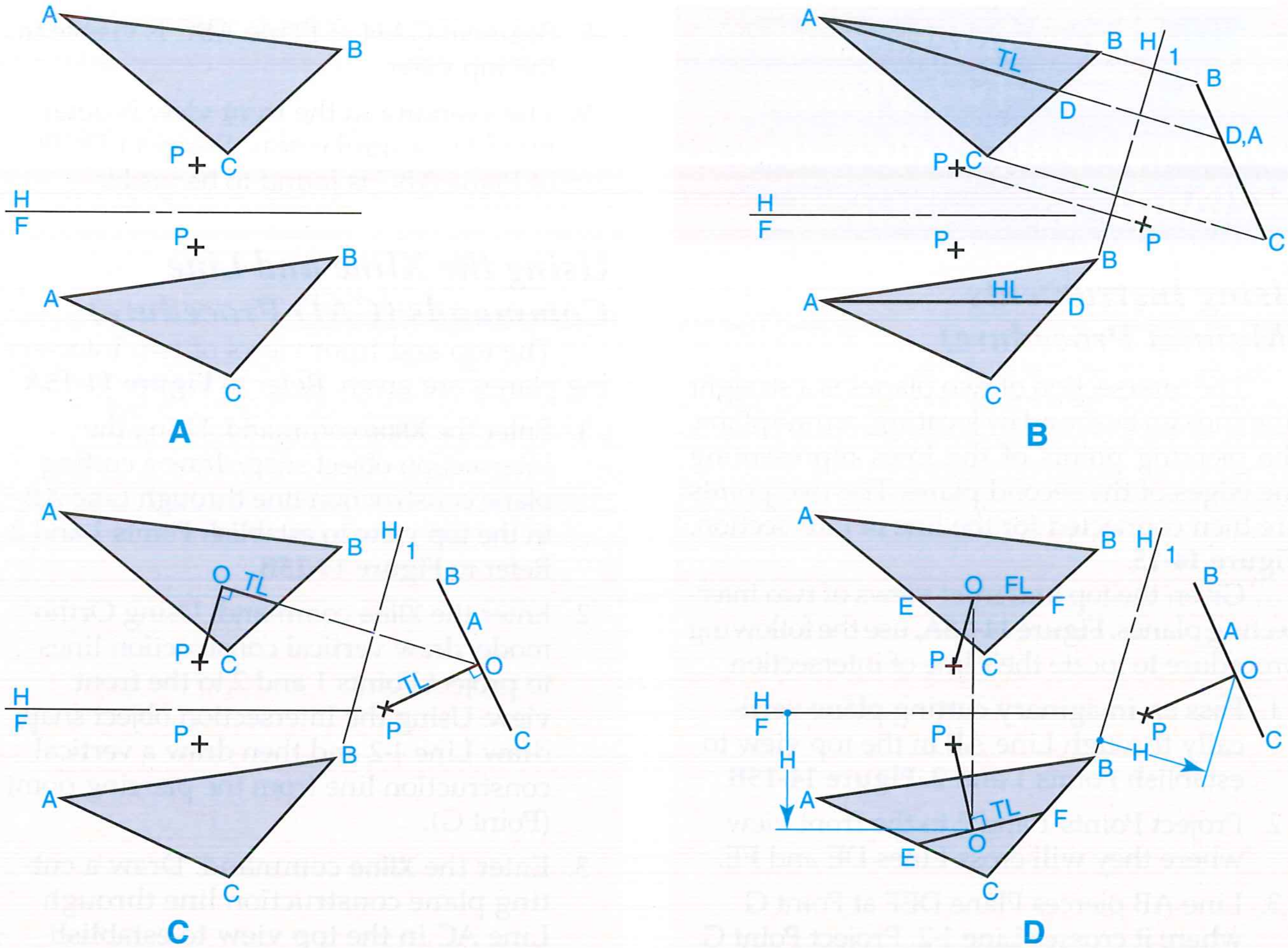

Figure 14-14. Using the auxiliary view method to draw a line through a point and perpendicular to an oblique plane.

Intersection of Two Planes (Orthographic Projection Method)

Using Instruments (Manual Procedure)

The intersection of two planes is a straight line and can be found by locating, on one plane, the piercing points of the lines representing the edges of the second plane. The two points are then connected for the line of intersection, **Figure 14-15**.

Given the top and front views of two intersecting planes, **Figure 14-15A**, use the following procedure to locate their line of intersection.

1. Pass an imaginary cutting plane vertically through Line AB in the top view to establish Points 1 and 2, **Figure 14-15B**.
2. Project Points 1 and 2 to the front view where they will cross Lines DE and FE.
3. Line AB pierces Plane DEF at Point G where it crosses Line 1-2. Project Point G to the top view.
4. In a similar fashion, pass a cutting plane through Line AC to establish points that are projected to the front view, crossing Lines DE and FE, **Figure 14-15C**.
5. Line AC pierces Plane DEF at Point H where it crosses Line 3-4. Project Point H to the top view. Draw the line of intersection in both views.
6. Analyze the crossing of Lines AH and DE in the top view for visibility. Line AH is found to be higher and, therefore, visible in the top view, **Figure 14-15D**.
7. Analyze the crossing of Lines AG and DE in the top view for visibility. Line AG is found to be higher and visible.
8. Segment GAH of Plane ABC is visible in the top view.
9. The visibility in the front view is determined in a similar way. Segment HGBC of Plane ABC is found to be visible.

Using the Xline and Line Commands (CAD Procedure)

The top and front views of two intersecting planes are given. Refer to **Figure 14-15A**.

1. Enter the **Xline** command. Using the Intersection object snap, draw a cutting plane construction line through Line AB in the top view to establish Points 1 and 2. Refer to **Figure 14-15B**.
2. Enter the **Xline** command. Using Ortho mode, draw vertical construction lines to project Points 1 and 2 to the front view. Using the Intersection object snap, draw Line 1-2 and then draw a vertical construction line from the piercing point (Point G).
3. Enter the **Xline** command. Draw a cutting plane construction line through Line AC in the top view to establish Points 3 and 4. Refer to **Figure 14-15C**. Draw vertical construction lines to project Points 3 and 4 to the front view. Using the Intersection object snap, draw Line 3-4 and then draw a vertical construction line from the piercing point (Point H).
4. Enter the **Line** command. Draw the line of intersection in both views.
5. Enter the **Line** command. Using a hidden linetype and object snaps, draw hidden lines in the top and front views where lines are not visible. Draw the remaining line segments as object lines. Refer to **Figure 14-15D**.

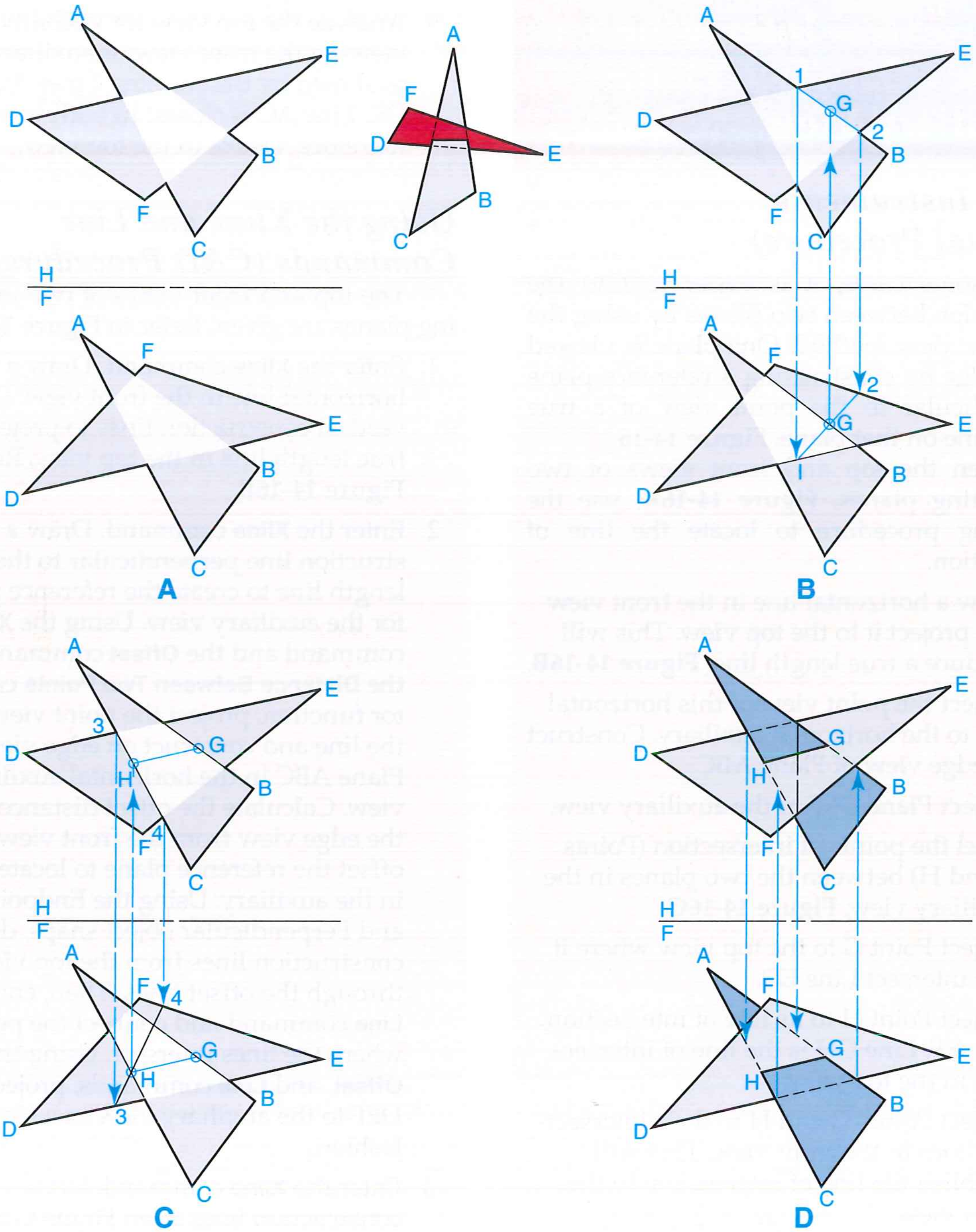

Figure 14-15. Locating the intersection of two planes using the orthographic projection method.

Intersection of Two Planes (Auxiliary View Method)

Using Instruments (Manual Procedure)

In some cases, it is easier to find the intersection between two planes by using the auxiliary view method. One plane is viewed as an edge by constructing a reference plane perpendicular to the point view of a true length line on that plane, **Figure 14-16.**

Given the top and front views of two intersecting planes, **Figure 14-16A**, use the following procedure to locate the line of intersection.

1. Draw a horizontal line in the front view and project it to the top view. This will produce a true length line, **Figure 14-16B.**
2. Project the point view of this horizontal line to the horizontal auxiliary. Construct an edge view of Plane ABC.
3. Project Plane DEF to the auxiliary view.
4. Label the points of intersection (Points G and H) between the two planes in the auxiliary view, **Figure 14-16C.**
5. Project Point G to the top view where it will intersect Line ED.
6. Project Point H to its line of intersection, Line EF. Line GH is the line of intersection in the top view.
7. Project Points G and H to their intersecting lines in the front view. This will establish the line of intersection in the front view.
8. Analyze the front view for visibility by looking at the top view from the crossing in the front view of Lines AB and DE. Line DE is found to be nearer and therefore visible in the front view, **Figure 14-16D.**
9. Analyze the top view for visibility by viewing the front view or auxiliary view as shown by the crossing Lines AC and DE. Line AC is closest in both views and therefore, visible in the top view.

Using the Xline and Line Commands (CAD Procedure)

The top and front views of two intersecting planes are given. Refer to **Figure 14-16A.**

1. Enter the **Xline** command. Draw a horizontal line in the front view. Draw vertical construction lines to project a true length line in the top view. Refer to **Figure 14-16B.**
2. Enter the **Xline** command. Draw a construction line perpendicular to the true length line to create the reference plane for the auxiliary view. Using the **Xline** command and the **Offset** command with the **Distance Between Two Points** calculator function, project the point view of the line and construct an edge view of Plane ABC in the horizontal auxiliary view. Calculate the offset distances for the edge view from the front view and offset the reference plane to locate points in the auxiliary. Using the Endpoint and Perpendicular object snaps, draw construction lines from the top view through the offset lines. Then, enter the **Line** command and connect the points where the lines intersect. Using the **Xline**, **Offset**, and **Line** commands, project Plane DEF to the auxiliary view in a similar fashion.
3. Enter the **Xline** command. Draw construction lines from Points G and H perpendicular to the reference plane to intersect Lines ED and EF in the top view. Enter the **Line** command and draw the line of intersection (Line GH). Refer to **Figure 14-16C.**

4. Enter the **Xline** command. Draw vertical construction lines to locate Points G and H in the front view. Enter the **Line** command and draw the line of intersection in the front view.
5. Enter the **Xline** command. Draw construction lines as needed to determine the visibility of lines in each view.
6. Enter the **Line** command. Using a hidden linetype and object snaps, draw hidden lines in the top and front views where lines are not visible. Draw the remaining line segments as object lines. Refer to **Figure 14-16D**.

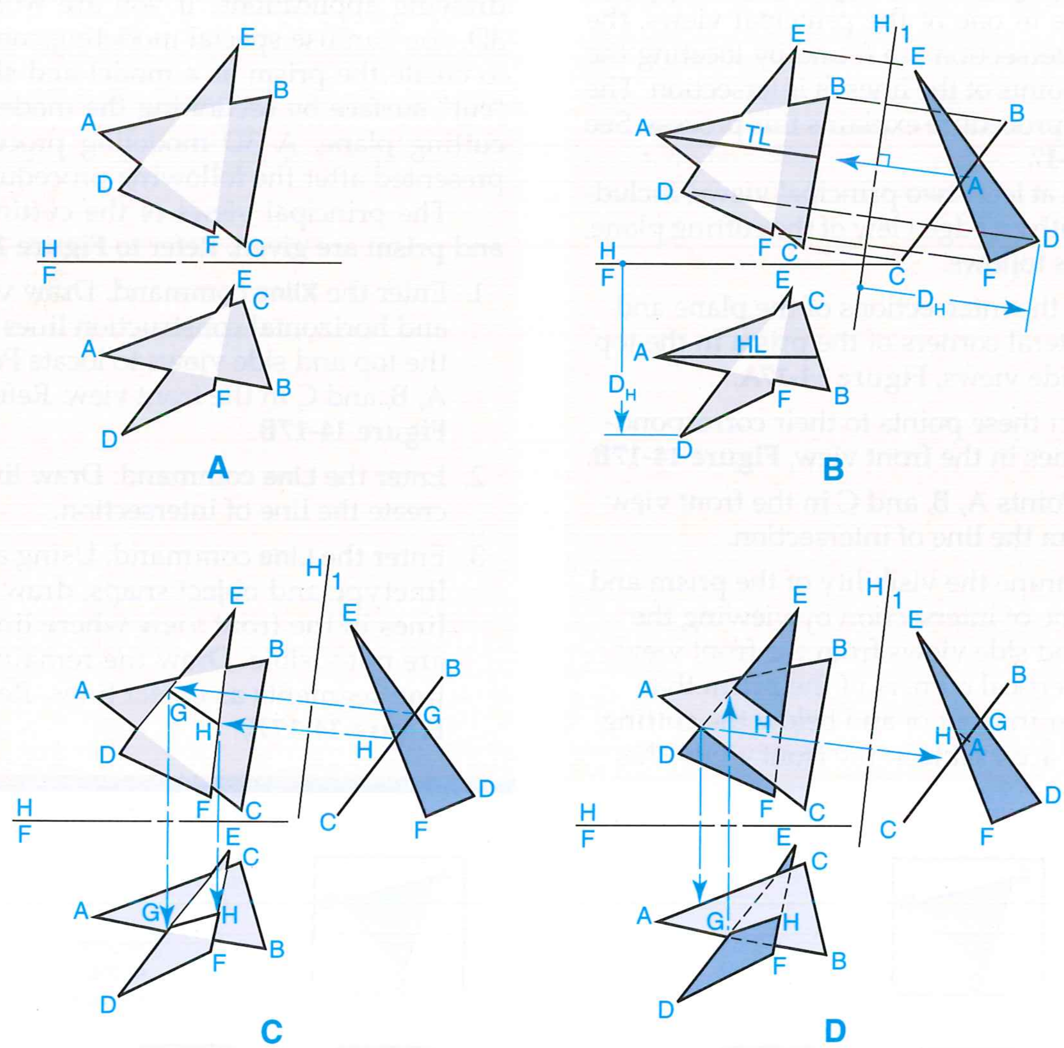

Figure 14-16. Locating the intersection of two planes using the auxiliary view method.

Intersection of an Inclined Plane and a Prism (Orthographic Projection Method)

Using Instruments (Manual Procedure)

When a plane cuts a prism and appears as an edge in one of the principal views, the lines of intersection are found by locating the piercing points of the lines of intersection. The following procedure explains this process. See **Figure 14-17**.

Given at least two principal views, including one with an edge view of the cutting plane, proceed as follows.

1. Label the intersections of the plane and the lateral corners of the prism in the top and side views, **Figure 14-17A**.
2. Project these points to their corresponding lines in the front view, **Figure 14-17B**.
3. Join Points A, B, and C in the front view to form the line of intersection.
4. Determine the visibility of the prism and the line of intersection by viewing the top and side views from the front view. The vertical corners of the prism that appear in front of and below the cutting plane are visible in the front view. The lateral corners that fall behind the plane are invisible in the front view. The line of intersection (Line AB) in the front view is invisible, as is a portion of the upper edge of the plane. This is because their locations are farther away from the frontal projection plane than the prism.

Using the Xline and Line Commands (CAD Procedure)

This procedure is used for 2D-based CAD drawing applications. If you are working in 3D, you can use special modeling commands to create the prism as a model and show the "cut" surface by sectioning the model with a cutting plane. A 3D modeling procedure is presented after the following procedure.

The principal views of the cutting plane and prism are given. Refer to **Figure 14-17A**.

1. Enter the **Xline** command. Draw vertical and horizontal construction lines from the top and side views to locate Points A, B, and C in the front view. Refer to **Figure 14-17B**.
2. Enter the **Line** command. Draw lines to create the line of intersection.
3. Enter the **Line** command. Using a hidden linetype and object snaps, draw hidden lines in the front view where lines are not visible. Draw the remaining line segments as object lines. Refer to **Figure 14-17B**.

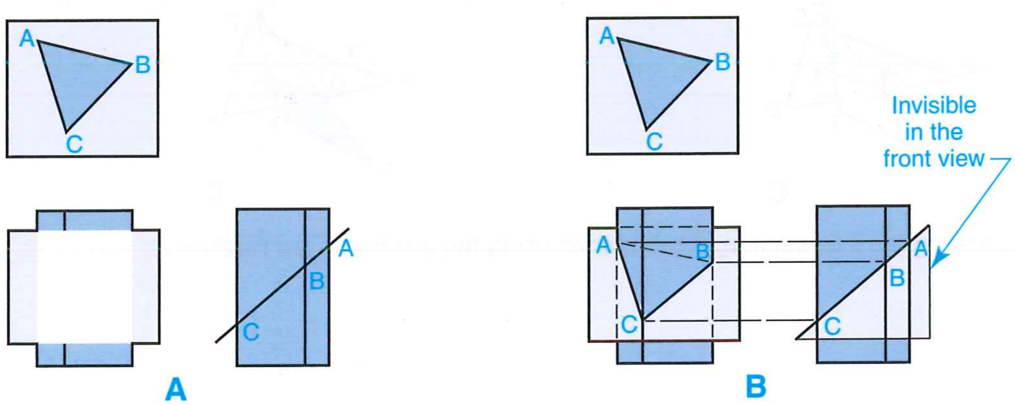

Figure 14-17. Locating the intersection of an inclined plane and a prism by using the orthographic projection method.

Intersection of an Inclined Plane and a Prism Using the Section Plane Command

The **Section Plane** command is used to create section views of 3D models. See **Figure 14-18**. It provides several ways to create a cutting plane to show interior features. If you need to locate the intersection of an inclined plane and a prism, it may be easiest to draw the prism as a 3D model and then orient a cutting plane at the proper angle with the **Section Plane** command to show the "cut" surface. The following procedure is used.

1. Using the appropriate 3D modeling commands and dimensions from orthographic views, create a prism, **Figure 14-18A**. The model can be created as a solid primitive or as an extrusion from 2D geometry. Enter the **Orbit** command and orient the viewing angle as desired.
2. Enter the **Xline** command. Draw a construction line to define the extents of the plane that will pass through the model. This may require you to change the viewing angle to an orthographic view where the plane appears as an edge.
3. Enter the **Section Plane** command. Using the drawing option of the command, pick the endpoints of the construction line to create the cutting plane, **Figure 14-18B**. If necessary, change the sectioning display to show the cut surface. Then, use the **Generate Section** option to generate a 3D section of the model. Refer to **Figure 14-18C** and **Figure 14-18D**. Orient the viewing angle as needed.

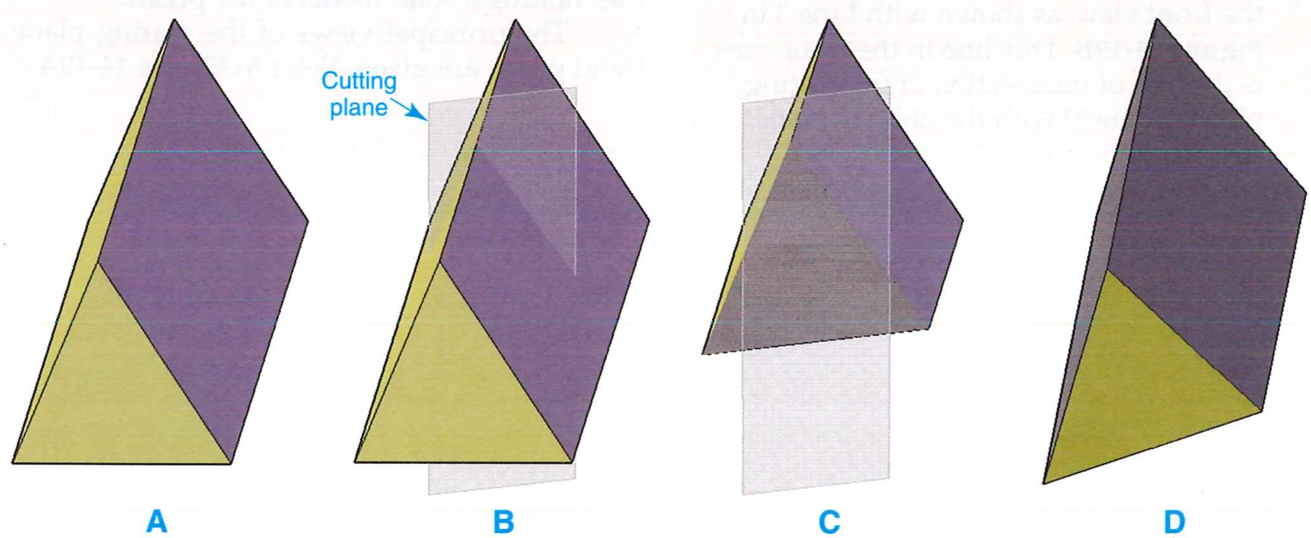

Figure 14-18. Locating the intersection of an inclined plane and a prism by using the **Section Plane** command with a 3D solid model. A—The prism is created as a solid primitive or extrusion. B—Points are picked with the **Section Plane** command to "pass" an inclined cutting plane through the model. C—The cut surface is shown by using the appropriate display option. D—A 3D section is created from the sectioned model to show the plane intersection.

Intersection of an Oblique Plane and a Prism (Cutting Plane Method)

Using Instruments (Manual Procedure)

When a cutting plane is oblique to the principal planes of projection, the cutting plane method is used to locate the intersection of a plane and a prism. Given two principal views of a plane and a prism that intersect, **Figure 14-19A**, use the following procedure.

1. Label the intersections of the plane and the lateral corners of the prism in the top view, **Figure 14-19B**.
2. Pass three cutting planes (Planes 1, 2, and 3) through the corners of the prism in the top view. Extend these through the edges of the oblique plane. These planes have been drawn horizontally, but can be in any direction *except* perpendicular to the projection plane.
3. Project the intersections of the cutting planes with the oblique plane edges to the front view, as shown with Line 3 in **Figure 14-19B**. This line in the front view is the line of intersection of the cutting plane (Plane 3) with the oblique plane.
4. Project the points in the top view where the three cutting planes intersect the corners of the prism to the front view. (That is, project Point B of Line 3 in the top view to Point B of Line 3 in the front view.)
5. These points in the front view represent the piercing points of the lateral corners of the prism. Since the prism and the oblique plane are intersecting plane figures, their lines of intersection will be straight lines. Join the piercing points with light construction lines and a straightedge.
6. The visibility is established by viewing the adjacent view for nearest location of lines and surfaces, **Figure 14-19C**. Once the visibility has been determined, darken the appropriate construction lines.

Using the Xline and Line Commands (CAD Procedure)

This procedure is used for 2D-based CAD drawing applications. If you are working in 3D, you can use the **Section Plane** command to locate a plane intersection with a prism by sectioning a solid model of the prism.

The principal views of the cutting plane and prism are given. Refer to **Figure 14-19A**.

1. Enter the **Xline** command. Using Ortho mode, draw three horizontal construction lines passing through the corners of the prism in the top view. Refer to **Figure 14-19B**.
2. Enter the **Xline** command. Using Ortho mode, draw three vertical construction lines to project the intersections of the cutting planes with the oblique plane edges to the front view.
3. Enter the **Xline** command. Using Ortho mode, draw three vertical construction lines to Project Points A, B, and C from the top view to the cutting planes in the front view.
4. Enter the **Line** command. Draw connecting lines to form the lateral corners of the prism in the front view. Determine the visibility of lines and use the appropriate linetype. Use object snaps as needed. Refer to **Figure 14-19C**.

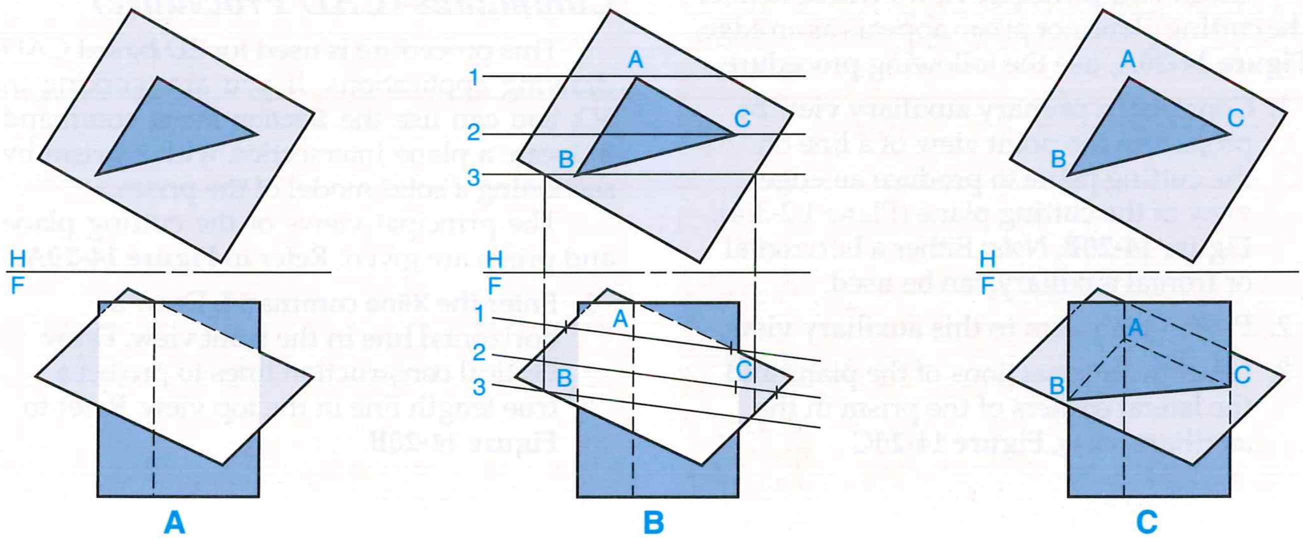

Figure 14-19. Locating the intersection of an oblique plane and a prism using the cutting plane method.

Intersection of an Oblique Plane and an Oblique Prism (Auxiliary View Method)

Using Instruments (Manual Procedure)

When neither the cutting plane nor the prism appears as an edge in any of the principal views, construct an auxiliary view to provide an edge view of the cutting plane. Once this view is constructed, the solution is similar to that for an inclined plane.

Given two principal views where neither the cutting plane nor prism appears as an edge, **Figure 14-20A**, use the following procedure.

1. Construct a primary auxiliary view by projecting the point view of a line on the cutting plane to produce an edge view of the cutting plane (Plane 1-2-3-4), **Figure 14-20B**. *Note:* Either a horizontal or frontal auxiliary can be used.
2. Project the prism to this auxiliary view.
3. Label the intersections of the plane and the lateral corners of the prism in the auxiliary view, **Figure 14-20C**.
4. Project these intersections to their corresponding lines in the top view. These points are the piercing points of the lateral corners of the prism and the cutting plane. Join these points to form the line of intersection in the top view.
5. Project the piercing points from the top view to their corresponding lines in the front view. Draw the line of intersection.
6. The visibility is established by checking adjacent views for the nearest location of surfaces.

Using the Xline and Line Commands (CAD Procedure)

This procedure is used for 2D-based CAD drawing applications. If you are working in 3D, you can use the **Section Plane** command to locate a plane intersection with a prism by sectioning a solid model of the prism.

The principal views of the cutting plane and prism are given. Refer to **Figure 14-20A**.

1. Enter the **Xline** command. Draw a horizontal line in the front view. Draw vertical construction lines to project a true length line in the top view. Refer to **Figure 14-20B**.

2. Enter the **Xline** command. Draw a construction line perpendicular to the true length line to create the reference plane for the auxiliary view. Using the **Xline** command and the **Offset** command with the **Distance Between Two Points** calculator function, project the point view of the line and construct an edge view of Plane 1-2-3-4 in the auxiliary view. Calculate the offset distances for the edge view from the front view and offset the reference plane to locate points in the auxiliary. Using the Endpoint and Perpendicular object snaps, draw construction lines from the top view through the offset lines. Then, enter the **Line** command and connect the points where the lines intersect. Using the **Xline, Offset**, and **Line** commands, project the prism to the auxiliary view in a similar fashion.
3. Enter the **Xline** command. Draw construction lines from the intersection points in the auxiliary view to the top view. Draw the lines perpendicular to the reference plane. Refer to **Figure 14-20C**.
4. Enter the **Xline** command. Draw vertical construction lines to locate the piercing points in the front view.
5. Enter the **Line** command. Draw connecting lines to form the lateral corners of the prism in both views. Determine the visibility of lines and use the appropriate linetypes. Use object snaps as needed.

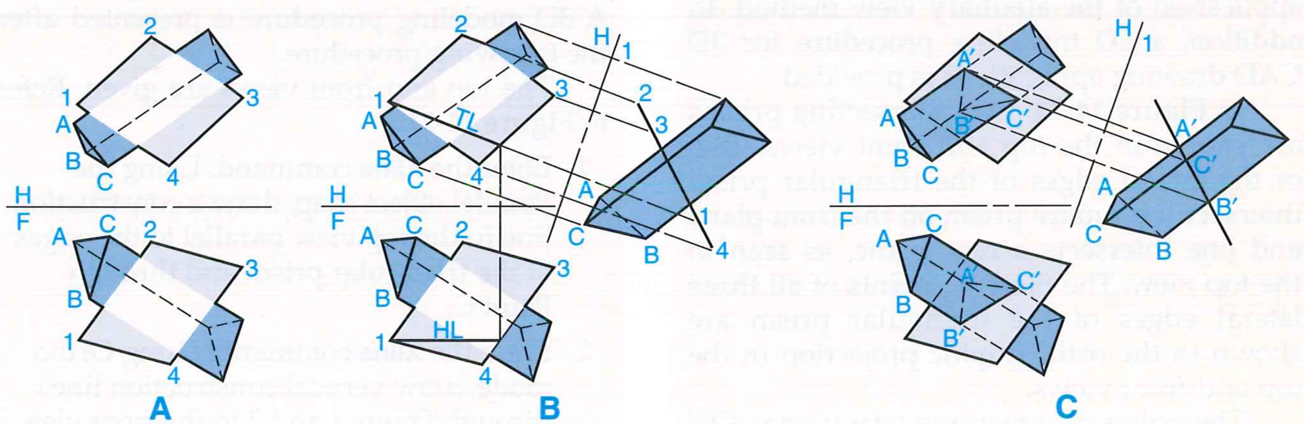

Figure 14-20. Locating the intersection of an oblique plane and an oblique prism using the auxiliary view method.

Intersection of Two Prisms (Cutting Plane Method)

Using Instruments (Manual Procedure)

The surfaces of prisms consist of a number of single planes. Therefore, the intersection of two prisms may be thought of as a prism intersecting with one or more single planes. The solution should be approached as outlined in the preceding sections, working with one plane at a time. Two 2D drawing applications are given for both manual and CAD drawing in this chapter. The first is an illustration of the cutting plane method. The second is an application of the auxiliary view method. In addition, a 3D modeling procedure for 3D CAD drawing applications is provided.

In **Figure 14-21**, two intersecting prisms are shown in the top and front views. Two of the lateral edges of the triangular prism intersect the square prism on the front plane and one intersects a rear plane, as seen in the top view. The piercing points of all three lateral edges of the triangular prism are shown in the orthographic projection in the top and front views.

The points at which the lateral edge CC′ intersects Planes E and F cannot be obtained directly by projection in the principal views. However, a vertical cutting plane, parallel to the lateral edges of the triangular prism, can be passed through Edge CC′ (where the undetermined points lie) and projected to the front view.

Given the top and front views, use the following procedure.

1. Draw a line in the top view parallel to the edges of the triangular prism and through Corner C, **Figure 14-21**. This line represents the vertical cutting plane.
2. Project Points 1 and 2, where the cutting plane intersects the edges of Planes E and F, to the front view to intersect the edges of the same planes at Points 1′ and 2′.
3. Project lines parallel to the triangular prism through Points 1′ and 2′ to intersect with Edge CC′ at Points 3 and 4, the piercing points of Edge CC′ with Planes E and F.
4. Join Points 5, 6, and 7, the piercing points of the lateral edges of the triangular prism, and Points 3 and 4 to complete the intersection between the two prisms.

Using the Xline and Line Commands (CAD Procedure)

This procedure is used for 2D-based CAD drawing applications. If you are working in 3D, you can use special modeling commands to construct the two intersecting prisms as solid models and then create a composite of the models to show the intersecting surfaces. A 3D modeling procedure is presented after the following procedure.

The top and front views are given. Refer to **Figure 14-21**.

1. Enter the **Xline** command. Using the Parallel object snap, draw a construction line in the top view parallel to the edges of the triangular prism and through Point C.
2. Enter the **Xline** command. Using Ortho mode, draw vertical construction lines through Points 1 and 2 to the front view to project Points 1′ and 2′.
3. Enter the **Xline** command. Using the Parallel object snap, draw construction lines parallel to the triangular prism through Points 1′ and 2′ to intersect Edge CC′ at Points 3 and 4.
4. Enter the **Xline** command. Draw vertical construction lines to project Points 5, 6, and 7 from the top view to the front view.
5. Enter the **Line** command. Draw connecting lines to form the lateral edges of the triangular prism and the lines of intersection of the two prisms. Use the appropriate linetype and use object snaps as needed.

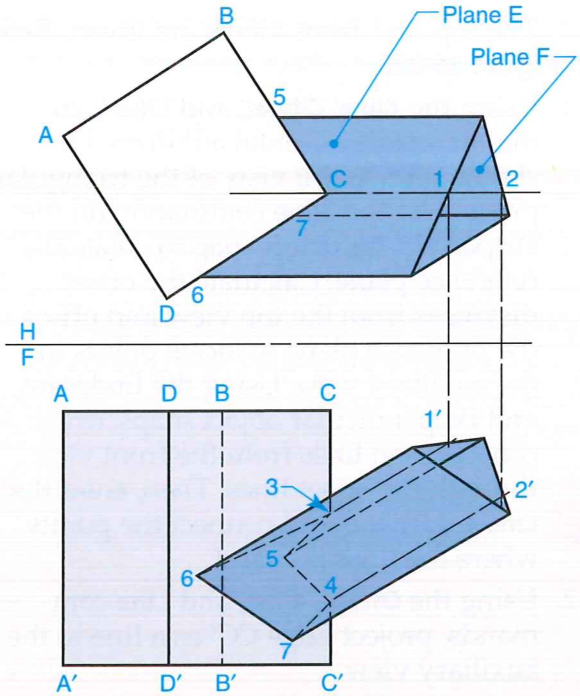

Figure 14-21. Locating the intersection of two prisms using the cutting plane method.

Intersection of Two Prisms Using the Intersect Command

The **Intersect** command is used to create a composite solid model from the intersection of two or more solids. See **Figure 14-22**. The resulting model represents the common volume shared by the objects. To define the intersection of a square prism and a triangular prism, it may be easiest to first draw the two prisms as 3D models and locate them as needed to form the desired intersection. The **Intersect** command is then used to create a solid formed by the intersecting surfaces. The following procedure is used.

1. Using the appropriate 3D modeling commands and dimensions from orthographic views, create a square prism and a triangular prism, **Figure 14-22A**. The models can be created as solid primitives or as extrusions from 2D geometry. Enter the **Orbit** command and orient the viewing angle as desired.
2. Using the **Move** and **Rotate 3D** commands, locate the triangular prism at the appropriate intersection with the square prism. Use the **Orbit** command to change the viewing angle as needed to position the two objects. Refer to **Figure 14-22B**.
3. Enter the **Intersect** command. Select each object. After completing the command, the composite solid model is generated. Refer to **Figure 14-22C**. Change the viewing angle as needed to display the surfaces of the model.

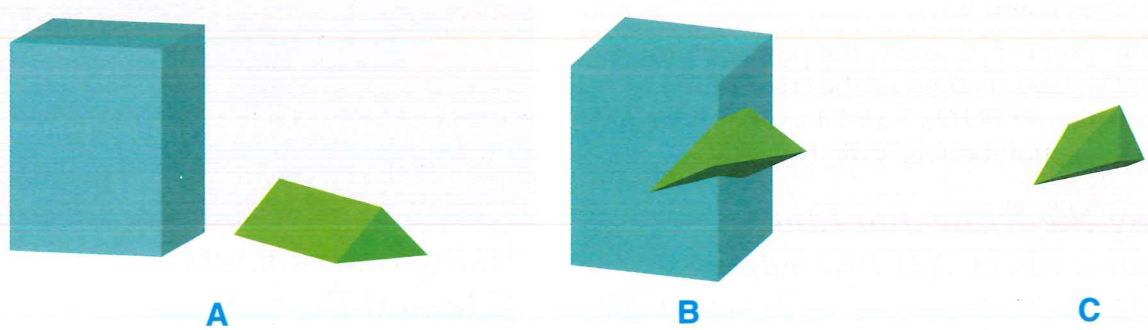

Figure 14-22. Locating the intersection of two prisms by using the **Intersect** command with two solid models. A—The square and triangular prisms are created as solid primitives or extrusions. B—The triangular prism is moved and rotated to create the intersection with the square prism. C—The **Intersect** command is used to create a composite solid model from the common volume of the two prisms.

Intersection of Two Prisms (Auxiliary View Method)

Using Instruments (Manual Procedure)

A second way to locate the intersection between two prisms is to use the auxiliary view method. The same two prisms used in the cutting plane method example (shown in **Figure 14-21**) are used with the auxiliary view method in the following procedure, **Figure 14-23**.

The piercing points of the lateral edges of the triangular prism are found by regular orthographic projection. The intersections of Edge CC′ with Planes E and F are found by drawing a frontal auxiliary view to project a point view of the end of the triangular prism. Edge CC′ is shown as a line in this view as well.

Given the top and front views, use the following procedure. Refer to **Figure 14-23**.

1. Construct a frontal auxiliary view that shows a point view of the triangular prism. Use a reference plane that is perpendicular to the lateral edges of the prism.
2. Project Edge CC′ as a line to locate Points 1 and 2. This is only part of the square prism that is necessary to find unknown points of intersection of the two prisms. The other piercing points can be located in the primary orthographic views.
3. Project Points 1 and 2 in the auxiliary view to intersect with Edge CC′ at Points 3 and 4, piercing points of Edge CC′ with Planes E and F.
4. Join Points 5, 6, and 7, the piercing points of the lateral edges of the triangular prism, and Points 3 and 4 to complete the intersection between the two prisms.

Using the Xline and Line Commands (CAD Procedure)

This procedure is used for 2D-based CAD drawing applications. If you are working in 3D, you can use the **Intersect** command to define the intersection between two prisms as previously discussed.

The top and front views are given. Refer to **Figure 14-23**.

1. Using the **Xline**, **Offset**, and **Line** commands, create a frontal auxiliary view showing the point view of the triangular prism. Use the **Xline** command and the Perpendicular object snap to create the reference plane. Calculate the offset distances from the top view and offset the reference plane to locate points in the auxiliary view. Using the Endpoint and Perpendicular object snaps, draw construction lines from the front view through the offset lines. Then, enter the **Line** command and connect the points where the lines intersect.
2. Using the **Offset**, **Xline**, and **Line** commands, project Edge CC′ as a line in the auxiliary view.
3. Enter the **Xline** command. Using the Parallel object snap, draw construction lines parallel to the triangular prism through Points 1 and 2 to intersect Edge CC′ at Points 3 and 4.
4. Enter the **Xline** command. Draw vertical construction lines to project Points 5, 6, and 7 from the top view to the front view.
5. Enter the **Line** command. Draw connecting lines to form the lateral edges of the triangular prism and the lines of intersection of the two prisms. Use the appropriate linetype and use object snaps as needed.

Intersection of a Plane and a Cylinder (Orthographic Projection Method)

Using Instruments (Manual Procedure)

When the intersecting plane appears as an edge in one of the principal views, the line of intersection between a plane and a cylinder can be found by projection between the principal

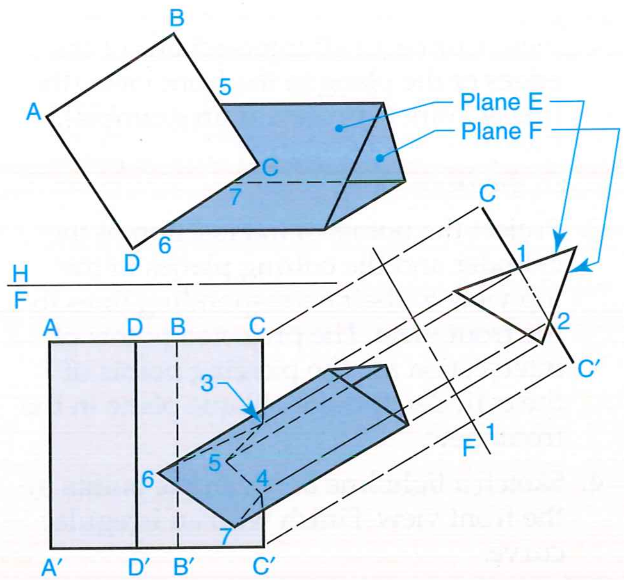

Figure 14-23. Locating the intersection of two prisms using the auxiliary view method.

views, **Figure 14-24**. Given the three principal views, use the following procedure.

1. Project the points of intersection of several randomly spaced parallel lines in the circular view (top view) of the cylinder to the front and side views.
2. Project points where these lines intersect with the edge view of the plane. Extend them to the front view to intersect with their corresponding lines of projection from the top view.
3. Connect these points of intersection to form the line of intersection between the plane and the cylinder.
4. The visibility is determined by checking adjacent views.

Using the Xline and Ellipse Commands (CAD Procedure)

This procedure is used for 2D-based CAD drawing applications. If you are working in 3D, you can use the **Section Plane** command to locate the intersection between a plane and a solid model of a cylinder.

The three principal views are given. Refer to **Figure 14-24**.

1. Enter the **Xline** command. Using Ortho mode, draw horizontal construction lines through the circular view (top view). Use the Quadrant, Center, and Nearest object snaps. Using Ortho mode and the Intersection object snap, draw vertical construction lines where the horizontal construction lines intersect the circular view.
2. Enter the **Xline** command. Using Ortho mode and the Intersection object snap, draw vertical construction lines at points where the horizontal construction lines in the top view intersect the diagonal miter line.
3. Enter the **Xline** command. Using Ortho mode and the Intersection object snap, draw horizontal construction lines at points where the vertical construction lines intersect the edge view of the plane in the side view.
4. Enter the **Ellipse** command. Using the **Arc** option, draw elliptical arcs connecting the points of intersection in the front view to form the line of intersection between the plane and the cylinder. Determine the visibility of lines and use the appropriate linetypes. Use object snaps as needed.

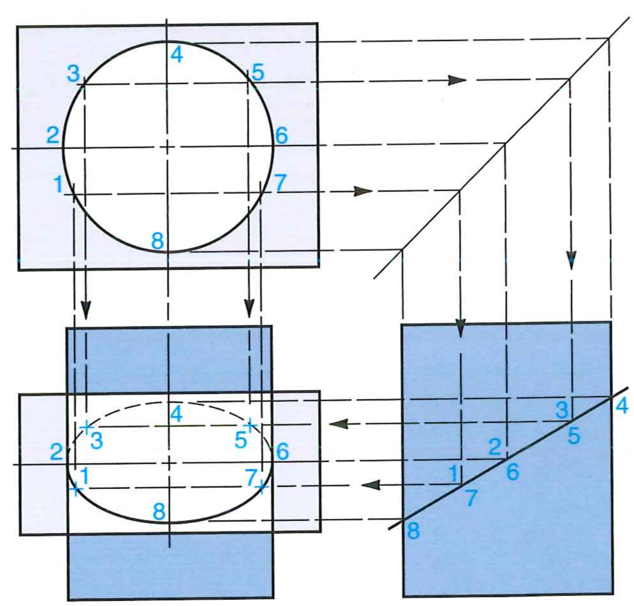

Figure 14-24. Locating the intersection of a plane and a cylinder using the orthographic projection method.

Intersection of an Oblique Plane and a Cylinder (Cutting Plane Method)

Using Instruments (Manual Procedure)

When the intersecting plane is oblique to the principal views, the line of intersection between a plane and a cylinder can be located by using the cutting plane method, **Figure 14-25**. Given the top and front views, use the following procedure.

1. Pass randomly spaced vertical cutting planes through the top view of the cylinder and plane. These cutting planes should run parallel to the edges of the plane. Select any number of planes at random locations. A greater number will produce a more accurate line of intersection.
2. Project the intersections of the cutting planes with the edges of the plane to their corresponding locations in the front view. Connect two intersections of the edges of the plane in the front view (the line at Point C is used as an example). Complete the location of cutting planes in the front view.
3. Project the points of intersection of the cylinder and the cutting planes in the top view to their corresponding lines in the front view. The projected points of intersection are the piercing points of the cylinder and the oblique plane in the front view.
4. Sketch a light line between the points in the front view. Finish with an irregular curve.
5. Visibility is determined by checking the two views.

Using the Xline and Spline Commands (CAD Procedure)

This procedure is used for 2D-based CAD drawing applications. If you are working in 3D, you can use the **Section Plane** command to locate the intersection between an oblique plane and a solid model of a cylinder.

The top and front views are given. Refer to **Figure 14-25**.

1. Enter the **Xline** command. Using the Parallel object snap, draw construction lines through the top view of the cylinder parallel to the edges of the plane.
2. Enter the **Xline** command. Using Ortho mode and the Intersection object snap, draw vertical construction lines from the intersections of the cutting planes with the edges of the plane. At the points where the lines intersect the edges of the plane in the front view, draw construction lines using the Intersection object snap to locate the cutting planes.
3. Enter the **Xline** command. Using Ortho mode, draw vertical construction lines from the points of intersection of the cylinder and the cutting planes in the top view to the front view.
4. Enter the **Spline** command. Draw splines connecting the points of intersection in the front view to form the line of intersection between the plane and the cylinder. Determine the visibility of lines and use the appropriate linetypes. Use object snaps as needed.

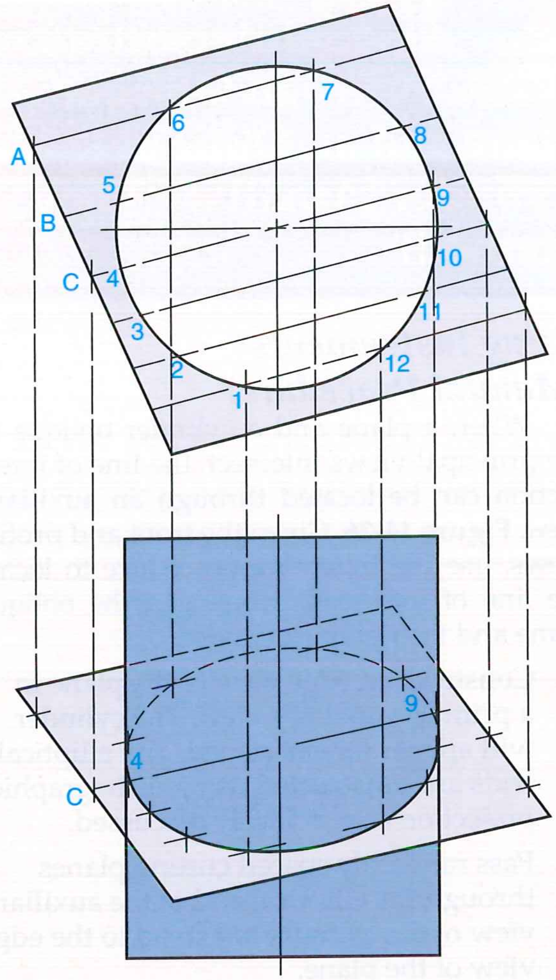

Figure 14-25. Locating the intersection of an oblique plane and a cylinder using the cutting plane method.

Intersection of an Oblique Plane and an Oblique Cylinder (Auxiliary View Method)

Using Instruments (Manual Procedure)

When a plane and a cylinder oblique to the principal views intersect, the line of intersection can be located through an auxiliary view, **Figure 14-26**. Given the front and profile views, use the following procedure to locate the line of intersection between the oblique plane and the oblique cylinder.

1. Construct an edge view of the plane in a primary auxiliary view. The cylinder will appear foreshortened. The elliptical ends are constructed using orthographic projection as previously discussed.
2. Pass randomly spaced cutting planes through the elliptical end of the auxiliary view of the cylinder to extend to the edge view of the plane.
3. Project points of intersection of the cutting planes from the elliptical end of the cylinder and the edge view of the plane in the auxiliary to the profile view. The projected points form the line of intersection in this view.
4. Project points of intersection on the ellipse in the profile view to the front view. Transfer measurements of the points from the auxiliary view to the front view. This forms the line of intersection in this view.
5. The visibility is determined by checking adjacent views.

Using the Xline and Spline Commands (CAD Procedure)

This procedure is used for 2D-based CAD drawing applications. If you are working in 3D, you can use the **Section Plane** command to locate the intersection between an oblique plane and a solid model of a cylinder.

The top and front views are given. Refer to **Figure 14-26**.

1. Using the **Xline, Offset,** and **Line** commands, create a primary auxiliary view showing the edge view of the plane. Use the **Xline** command and the Perpendicular object snap to create the reference plane. Calculate offset distances from the front view and offset the reference plane to locate points in the auxiliary view. Using the Endpoint and Perpendicular object snaps, draw construction lines from the profile view through the offset lines. Then, enter the **Line** command and connect the points where the lines intersect. Enter the **Xline** command and draw construction lines to locate construction points for the elliptical ends of the cylinder. Draw the ends using the **Spline** command. Use the appropriate linetypes.

2. Enter the **Xline** command. Using the Parallel object snap, draw construction lines through the elliptical end of the cylinder to the edge view of the plane.
3. Enter the **Xline** command. Using the Perpendicular and Parallel object snaps, draw construction lines from the auxiliary view to the profile view to locate points for the line of intersection.
4. Enter the **Spline** command. Draw splines connecting the points of intersection in the profile view to form the line of intersection between the plane and the cylinder. Determine the visibility of lines and use the appropriate linetypes. Use object snaps as needed.
5. Enter the **Xline** command. Draw construction lines from the points of intersection in the profile view to the front view. Locate points for the line of intersection using calculated measurements from the auxiliary view.
6. Enter the **Spline** command. Draw splines connecting the points of intersection in the front view to form the line of intersection. Determine the visibility of lines and use the appropriate linetypes. Use object snaps as needed.

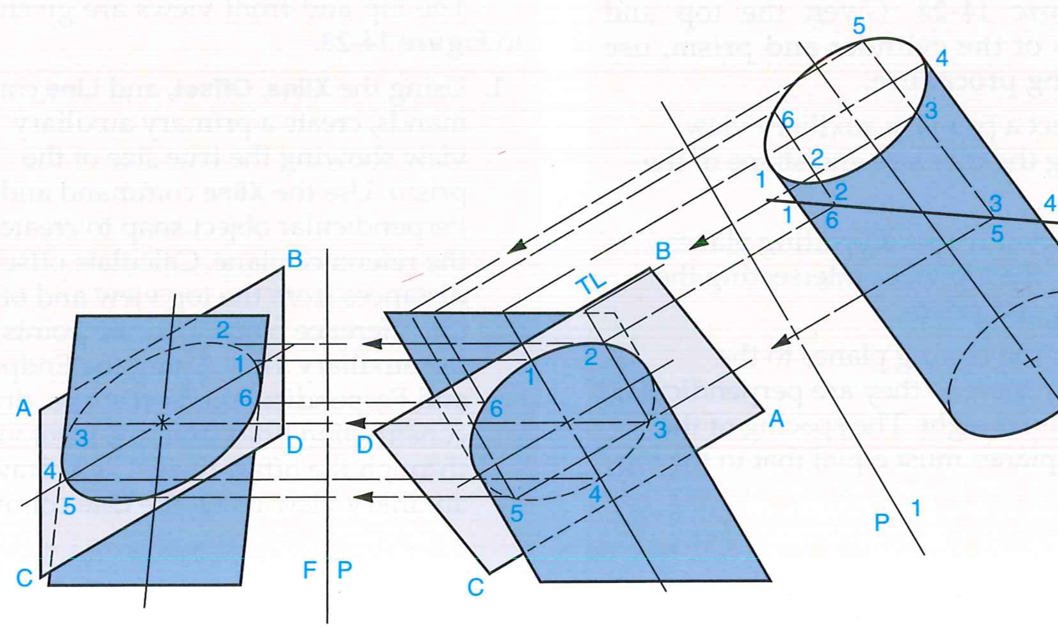

Figure 14-26. Locating the intersection of an oblique plane and an oblique cylinder using the auxiliary view method.

Intersection of a Cylinder and a Prism

Using Instruments (Manual Procedure)

The intersection of a cylinder and a prism can be located by approaching the solution as a series of single planes intersecting a cylinder, **Figure 14-27**. Each plane is treated one at a time. Since one or more of the planes of the prism are oblique in the principal views, an auxiliary view is needed to project the true shape of the prism, **Figure 14-28**. Given the top and front views of the cylinder and prism, use the following procedure.

1. Construct a primary auxiliary view showing the true size and shape of the prism.
2. Pass randomly spaced cutting planes through the top view, intersecting the cylinder and prism.
3. Transfer the cutting planes to the auxiliary view so they are perpendicular to the line of sight. The spacing of the cutting planes must equal that in the top view.
4. Project corresponding points of intersection between the cutting planes and the cylinder and prism in the top and auxiliary views to the front view. The projected points locate the lines of intersection.
5. Check the adjacent views for visibility.

Using the Xline and Spline Commands (CAD Procedure)

This procedure is used for 2D-based CAD drawing applications. If you are working in 3D, you can use the **Intersect** command to locate the intersection between a cylinder and a prism after creating the two objects as solid models.

The top and front views are given. Refer to **Figure 14-28**.

1. Using the **Xline**, **Offset**, and **Line** commands, create a primary auxiliary view showing the true size of the prism. Use the **Xline** command and the Perpendicular object snap to create the reference plane. Calculate offset distances from the top view and offset the reference plane to locate points in the auxiliary view. Using the Endpoint and Perpendicular object snaps, draw construction lines from the front view through the offset lines. Then, draw the auxiliary view using the **Line** command.

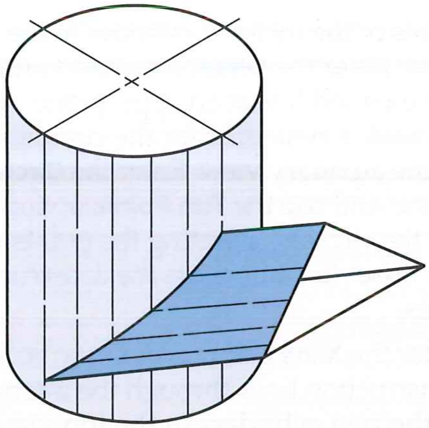

Figure 14-27. The intersection of a cylinder and a prism can be thought of as a number of single planes intersecting a cylinder.

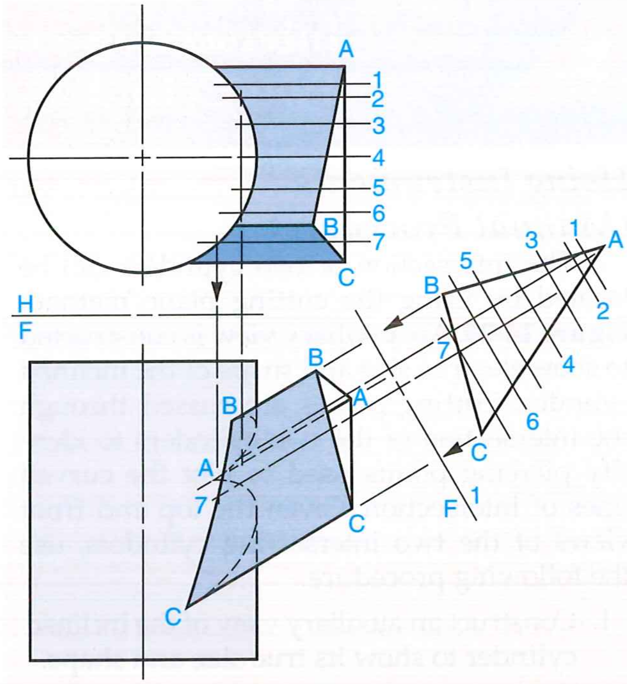

Figure 14-28. Locating the intersection of a cylinder and a prism using the auxiliary view method.

2. Enter the **Xline** command. Using Ortho mode, draw a series of horizontal construction lines intersecting the cylinder and prism in the top view.
3. Enter the **Offset** command. Using calculated distances from the top view, offset the reference plane in the auxiliary view to create the cutting planes.
4. Enter the **Xline** command. Draw vertical construction lines from the top view where the cutting planes intersect the cylinder and prism. Draw construction lines from the auxiliary view where the cutting planes intersect the prism.
5. Enter the **Spline** command. Draw splines connecting the points of intersection in the front view to form the lines of intersection. Determine the visibility of lines and use the appropriate linetypes. Use object snaps as needed.

Intersection of Two Cylinders

Using Instruments (Manual Procedure)

The intersection of two cylinders can be located by using the cutting plane method, **Figure 14-29**. An auxiliary view is constructed to show the true size and shape of the inclined cylinder. Cutting planes are passed through the intersection of the two cylinders to identify piercing points used to plot the curved lines of intersection. Given the top and front views of the two intersecting cylinders, use the following procedure.

1. Construct an auxiliary view of the inclined cylinder to show its true size and shape.
2. Pass randomly spaced cutting planes through the intersection of the two cylinders in the top view.
3. Transfer the cutting planes to the auxiliary view. These lines must be perpendicular to the line of sight. The spacing of the cutting planes must equal that in the top view.
4. Project the corresponding points of intersection between the cutting planes and the cylinders to the front view from the top and auxiliary views. The projected points locate the lines of intersection.
5. Check adjacent views for the visibility.

Using the Xline and Spline Commands (CAD Procedure)

This procedure is used for 2D-based CAD drawing applications. If you are working in 3D, you can use the **Intersect** command to define the intersection between two cylinders after creating them as solid models.

The top and front views are given. Refer to **Figure 14-29**.

1. Using the **Xline**, **Offset**, and **Circle** commands, create an auxiliary view showing the true size of the inclined cylinder. Enter the **Xline** command and draw construction lines perpendicular to the top and bottom edges of the inclined cylinder in the front view. Enter the **Offset** command and offset the inclined line at an appropriate distance to create a centerline for the circular feature in the auxiliary view. Enter the **Circle** command and use the **Two Points** option to create the circle by selecting the points where the offset line intersects the construction lines.
2. Enter the **Xline** command. Draw horizontal construction lines through the intersection of the two cylinders in the top view.
3. Enter the **Offset** command. Using calculated distances from the top view, offset the centerline in the auxiliary view to transfer the cutting planes.
4. Enter the **Xline** command. Draw vertical construction lines from the top view where the cutting planes intersect the cylinders. Draw construction lines from the auxiliary view where the cutting planes intersect the cylinder.
5. Enter the **Spline** command. Draw splines connecting the points of intersection in the front view to form the lines of intersection. Determine the visibility of lines and use the appropriate linetypes. Use object snaps as needed.

Intersection of an Inclined Plane and a Cone

Using Instruments (Manual Procedure)

When the intersecting plane appears as an edge in one of the principal views, the line of intersection between an inclined plane and a cone can be located by projection between the principal views, **Figure 14-30**. Given the top and front views, use the following procedure.

1. In the top view, where the base of the cone appears as a circle, draw a number of randomly spaced diameters intersecting this circle.

2. Project the points of intersection to the base of the cone in the front view. Connect the projected points with the apex of the cone.
3. The lines from the base to the apex locate the piercing points on the inclined plane. Project these points to the top view to the corresponding diametric lines.
4. Connect the points of intersection in the top view to form the line of intersection. The line of intersection in the front view coincides with the inclined plane.

Using the Xline and Spline Commands (CAD Procedure)

This procedure is used for 2D-based CAD drawing applications. If you are working in 3D, you can use the **Section Plane** command to locate the intersection between an inclined plane and a solid model of a cone.

The top and front views are given. Refer to **Figure 14-30**.

1. Enter the **Xline** command. Using the Center object snap, draw several diametric lines intersecting the circle in the top view.
2. Enter the **Xline** command. Draw vertical construction lines from the points of intersection to the base of the cone in the front view. Then, draw construction lines from the projected points to the apex of the cone. Use object snaps as needed.
3. Enter the **Xline** command. Draw construction lines from the piercing points on the inclined plane to the top view to the corresponding diametric lines.
4. Enter the **Spline** command. Draw a spline connecting the points of intersection in the top view to form the line of intersection. Use object snaps as needed.

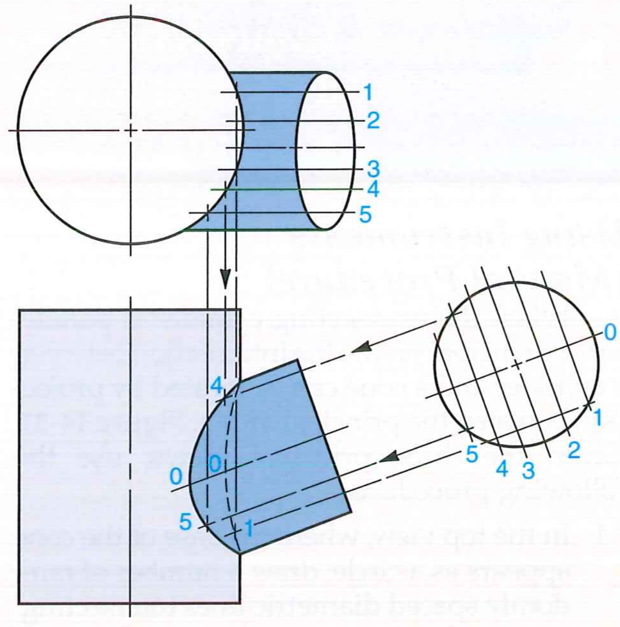

Figure 14-29. Locating the intersection between two cylinders using the cutting plane method.

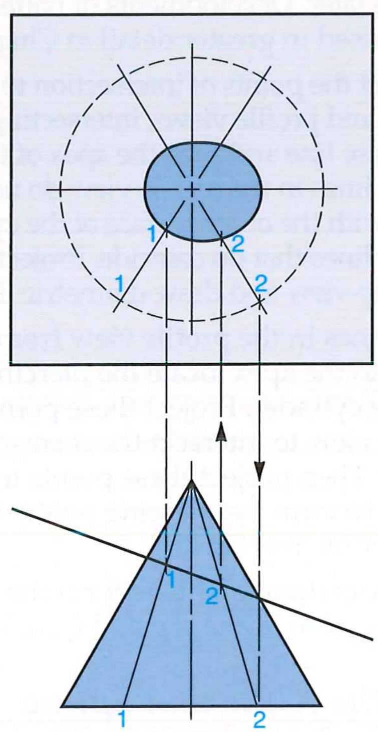

Figure 14-30. Locating the intersection of a plane and a cone using the orthographic projection method.

Intersection of a Cylinder and a Cone

Using Instruments (Manual Procedure)

When the intersecting cylinder is parallel to the principal views, the intersection between a cylinder and a cone can be located by projection between the principal views, **Figure 14-31**. Given the three principal views, use the following procedure.

1. In the top view, where the base of the cone appears as a circle, draw a number of randomly spaced diametric lines intersecting the circle. *Note:* If a pattern of the surface is to be developed later for the piece, 12 to 16 diametric lines should be equally spaced. (If this object is to be made out of sheet metal, for example, a pattern will need to be made later. Developments of patterns are discussed in greater detail in Chapter 15.)
2. Project the points of intersection to the front and profile views, intersecting first the base line and then the apex of the cone. If the lines in the profile view do not coincide with the outer surface of the cylinder, draw lines that do coincide. Project back to the top view and draw diametric lines.
3. The lines in the profile view from the base to the apex locate the piercing points of the cylinder. Project these points to the front view to intersect the corresponding lines. Then project these points to the top view to form the piercing points in the line of intersection.
4. Connect these points to form the line of intersection in the top and front views.

Using the Xline and Spline Commands (CAD Procedure)

This procedure is used for 2D-based CAD drawing applications. If you are working in 3D, you can use the **Intersect** command to define the intersection between a cylinder and a cone after creating the objects as solid models.

The three principal views are given. Refer to **Figure 14-31**.

1. Enter the **Xline** command. Using the Center object snap, draw a number of diametric lines intersecting the circle in the top view.
2. Enter the **Xline** command. Draw vertical construction lines from the points of intersection to the base of the cone in the front view. Draw horizontal and vertical construction lines to project the points of intersection to the base of the cone in the profile view. In both views, draw construction lines from the projected points to the apex of the cone. Use object snaps as needed.
3. Enter the **Xline** command. Draw horizontal construction lines from the points of intersection in the profile view to the corresponding lines in the front view. Then, draw vertical construction lines from the piercing points in the front view to the corresponding lines in the top view.
4. Enter the **Spline** command. Draw a spline connecting the points of intersection in the front view to form the line of intersection. Then, draw a spline connecting the points of intersection in the top view to form the line of intersection. Use object snaps as needed.

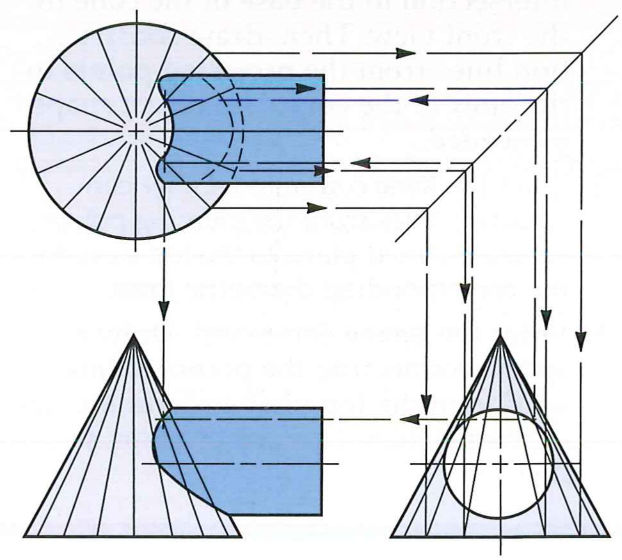

Figure 14-31. Locating the intersection between a cylinder and a cone using the orthographic projection method.

Summary of Projection Methods Applied in Locating Intersections

Three methods of locating lines of intersection between geometric forms have been presented in this chapter. These three methods are the orthographic projection method, the cutting plane method, and the auxiliary view method. When selecting the appropriate method to use, consider the following guidelines.

The ***orthographic projection method*** should be used when the object is parallel to one or more principal planes of projection. Also, the cutting plane representing the line of intersection must be shown as an edge in one of the principal planes of projection.

The ***cutting plane method*** should be used when the plane representing the line of intersection is oblique to all of the principal planes of projection.

The ***auxiliary view method*** should be used when both the intersecting plane and the object are oblique to the principal planes of projection.

Chapter Summary

When two objects join or pass through each other, the line formed at the junction of their surfaces is known as an intersection. Intersections and their solutions are classified on the basis of the types of geometrical surfaces involved. Two broad classifications of geometrical surfaces are ruled geometrical surfaces and double-curve geometrical surfaces. Ruled geometrical surfaces are generated by moving a straight line. Double-curve geometrical surfaces are generated by a curved line revolving around a straight line in the plane of the curve. Double-curve surfaces cannot be developed, but a development can be approximated.

Several spatial relationships need to be understood before solving intersection and development problems. These include the following:

- Point location on a line.
- Intersecting and nonintersecting lines in space.
- Visibility of crossing lines in space.
- Visibility of a line and a plane in space.
- Location of a piercing point of a line with a plane.
- Location of a line through a point and perpendicular to an oblique plane.

Intersections can be formed from two-dimensional geometric objects, three-dimensional geometric objects, or combinations of both. Intersections can be drawn using manual or CAD methods. Common intersection problems involving geometric objects include the following:

- Intersection of two planes.
- Intersection of an inclined plane and a prism.
- Intersection of two prisms.
- Intersection of a plane and a cylinder.
- Intersection of an oblique plane with an oblique cylinder.
- Intersection of a cylinder and a prism.
- Intersection of two cylinders.
- Intersection of an inclined plane and a cone.
- Intersection of a cylinder and a cone.

Review Questions

1. What is an *intersection*?
2. What are *ruled geometrical surfaces*?
3. Name the three types of ruled geometric surfaces.
4. If a surface can be _____, it can be "unfolded" or "unrolled" into a single plane.
5. What type of surface cannot be developed into a single plane?
6. What is a double-curve geometrical surface?
7. Double-curve surfaces, like warped surfaces, cannot be developed into _____ surfaces.
8. Lines are composed of an infinite number of _____.
9. Lines that appear to cross in space are not necessarily _____ lines.
10. The _____ of crossing lines is established by projecting the crossing point of the lines from an adjacent view.
11. What is a *piercing point*?
12. When a plane cuts a prism and appears as an edge in one of the principal views, the lines of intersection are found by locating the _____ of the lines of intersection.
13. What is the purpose of the **Section Plane** command in CAD drafting?
14. The surfaces of prisms consist of a number of single _____.
15. What CAD command is used to create a composite solid model from the intersection of two or more solids?
16. What are the three methods of locating lines of intersection between geometric forms?

Problems and Activities

The problems in the following sections are designed to give you practice in locating intersections between objects. These problems can be completed manually or using a CAD system. Draw each problem as assigned by your instructor.

Accuracy is extremely important in the solution of intersection problems. If you are drawing manually, use a sharp pencil. Guidelines and construction lines should be drawn very lightly. This will help to increase your accuracy in locating points and intersections. It will also help to minimize the need for erasures.

Use an A-size sheet for each problem. Draw the given views for each problem. The problems are shown on 1/4" graph paper to help you locate the objects. Complete each problem as indicated. If you are drawing manually, use manual projection techniques and label the points, lines, and planes to show your construction procedure. Use one of the layout sheet formats given in the Reference Section. If you are using a CAD system, use the appropriate drawing commands and tools to complete each problem. Create layers and set up drawing aids as needed. Save each problem as a drawing file and save your work frequently.

Locating Intersecting and Nonintersecting Lines in Space

1. For Problems A–D, determine whether the lines intersect or merely cross in space. Use orthographic projection methods. Label your solution. If you are drawing manually, use the Layout A-4 or Layout A-5 sheet format with only a vertical or horizontal division. Place two problems on a sheet. If you are using a CAD system, draw a title block or use a template. After solving the problems, consider the following question: Is there a way of studying views to determine whether lines intersect? Explain your answer.