3. Orthographic projection and Multi-View Projection

Orthographic projection is a method of producing a number of separate two-dimensional inter-related views, which are mutually at right angles to each other. Using this projection, even the most complex shape can be fully described. This method, however, does not create an immediate three-dimensional visual picture of the object, as does pictorial projection. The ability to visualize or think in three dimensions is essential to the competent reading of drawings and should be developed even before the skills required producing the accurate engineering drawings.

Visualization is best achieved through the use of models in conjunction with drawings, to promote an understanding of reading drawings and three-dimensional thinking. Orthographic projection is based on two principal planes — one horizontal (HP) and one vertical (VP) — intersecting each other and forming right angles and quadrants as shown in Figure 3.1.
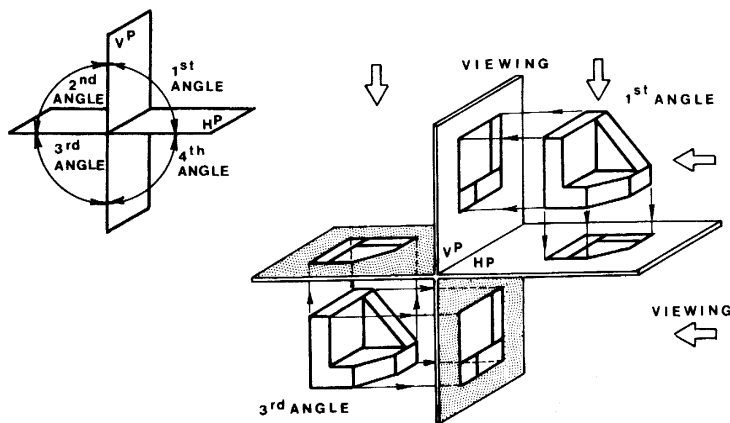

Figure 3.1 Principles of orthographic projection

Multi-view (multiplanar) projection is a method by which the exact shape of an object can be represented by two or more separate views produced on projection planes that are at right angles to each other.

3.1. PROJECTIONS

The goal in engineering graphics, whether it is freehand sketching or CAD, is to represent a physical object Objects can be shown as *3-D projections* or *Multiview projections.* 3-D projections are useful in that they provide an image that is similar to the image in the designer's mind's eye. But 3-D projections are often weak in providing adequate details of the object, and there is often some distortion of the object. For instance, a circular hole becomes an ellipse in an isometric 3-D projection. *Multiview projections* are used to overcome the weaknesses of 3-D projections. Multiview projections are a collection of flat 2-D drawings of the different sides of an object.

Only two forms of orthographic projections are used: first-angle ('European ISO-E') and third-angle ('American ISO-A').

3.1.1 First-Angle Projection (ISO-E)

In first-angle projection, an object is positioned in the space of the first-angle quadrant between two planes Figure 3.2(a). A view of the object is projected by drawing parallel projecting lines, or projectors, from the object to the vertical principal plane (VP). This view on VP is called a front view. A view similarly projected on to the horizontal principal plane (HP) is called a plan view.
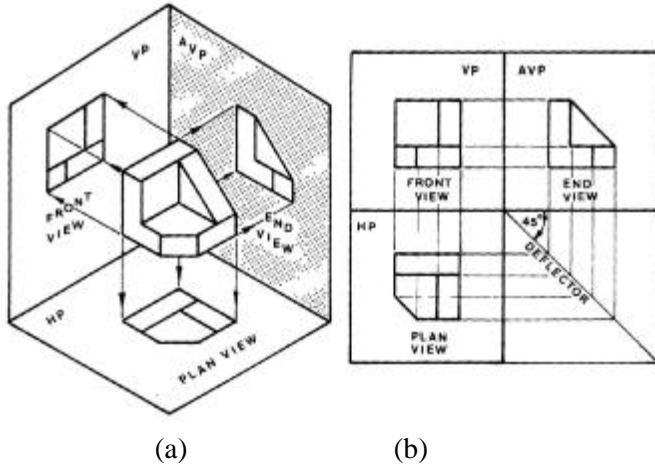

(a)   (b)

Figure 3.2 First-angle projection

For the complete description of the object, an additional plane, called the auxiliary vertical plane (AVP), is used at 90° to the principal planes, and the view projected on to that plane is called an end view. By means of projectors, all three planes can be unfolded and three views of the object can be shown simultaneously on drawing paper as in Figure 3.2(b). The end view is projected horizontally and the plan view vertically from the front view. Sometimes it is necessary to show six views of an object as in Figure 3.3(a). As a rule, the minimum number of views should be used, especially to represent simple objects.
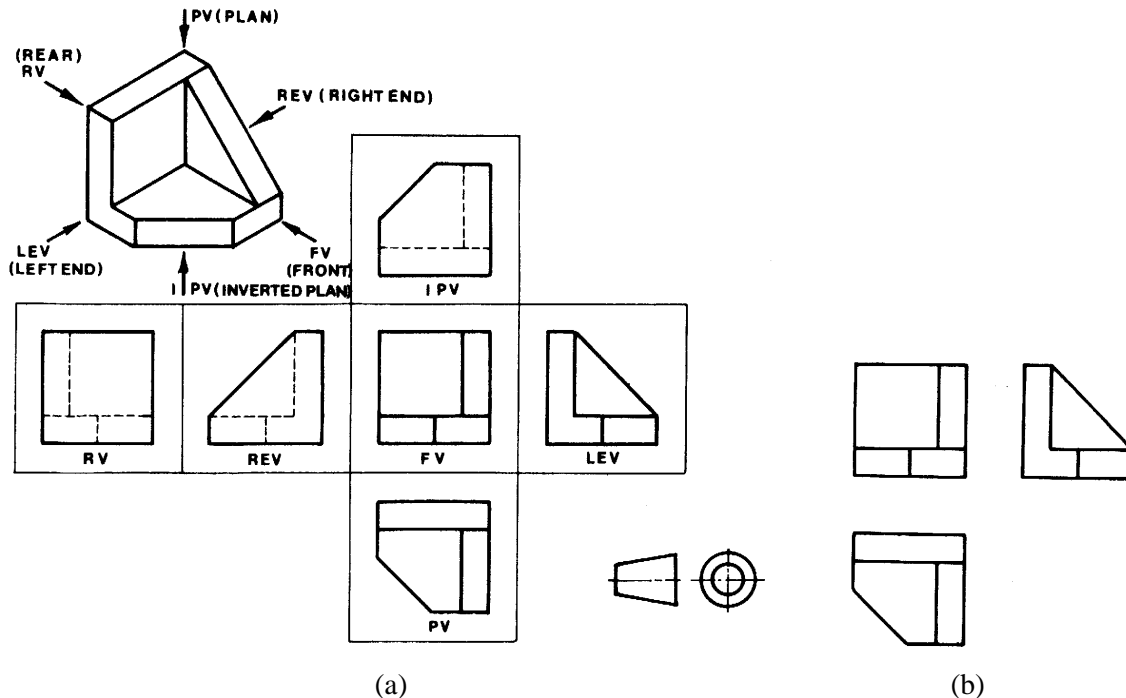

(a)   (b)

Figure 3.3 Views in first-angle projection

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In common practice only three views are used: a front view, an end view, and a plan view. These three views are sufficient for a complete description of objects as shown in Figure 3.3(b).

3.1.2. Third-Angle Projection (ISO-A)

In third-angle projection, an object is positioned in the space of the third-angle quadrant between two principal planes. The planes are imagined to be transparent, and the projected views of the object are viewed through the planes as shown in Figure 3.4.
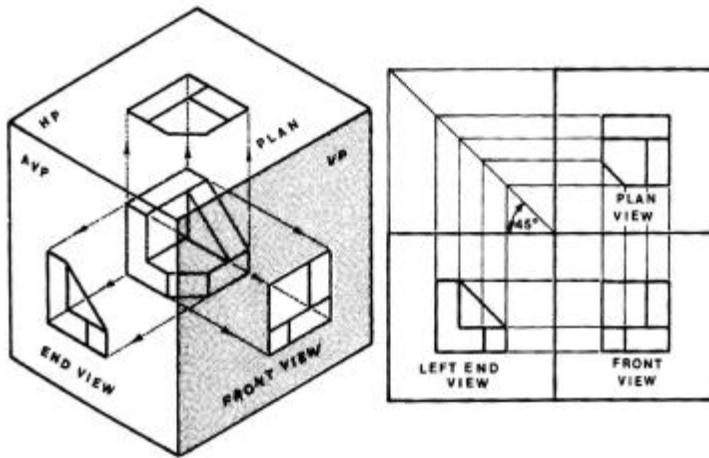

Figure 3.4 Third-angle projection

In common practice, only three of the six possible views as shown in Figure 3.5(a) are used for complete description of an object as in Figure 3.5(b). Either of the two end views may be chosen.
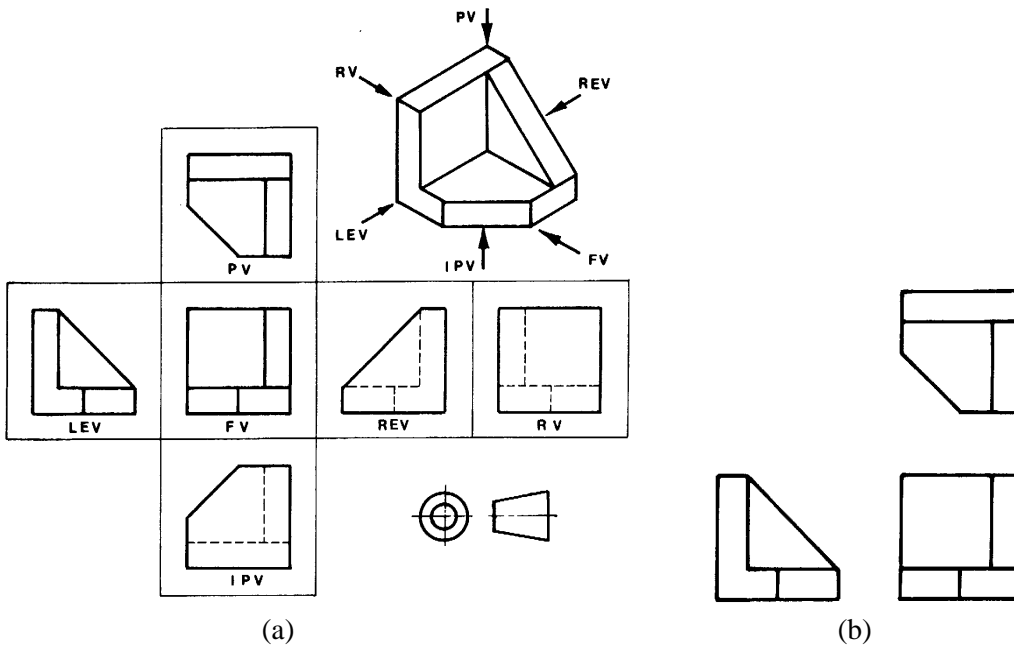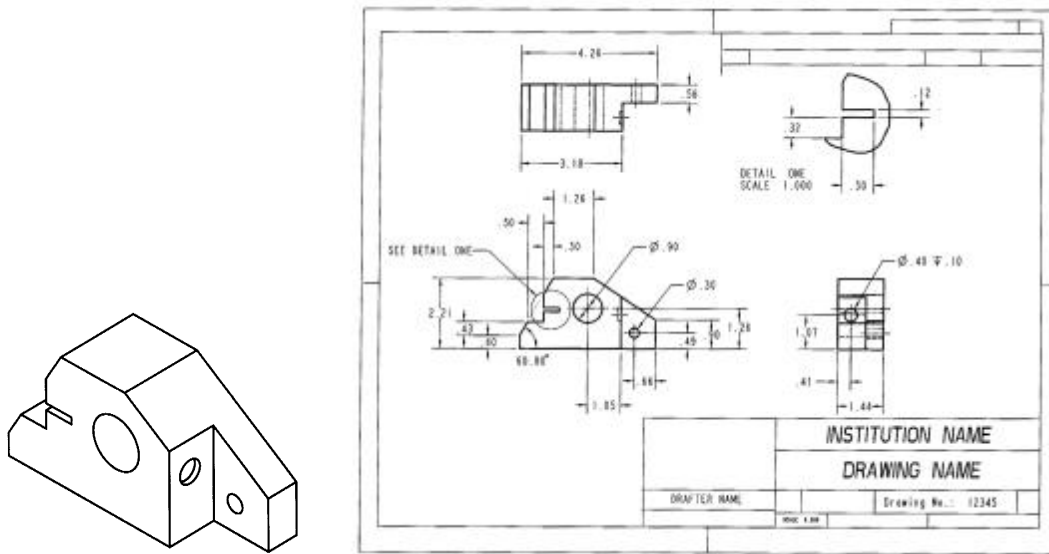

(a)   (b)

Figure 3.5 Views in third-angle projection

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3.2. MULTIVIEW DRAWINGS

Multiview drawing is classified as a parallel projection technique, because the lines of sight used to view the object are parallel. This method of viewing an object results in a single view, with only two of the three dimensions represented.

The standard means of multiview projection in engineering graphics is what we have referred to earlier as the *orthographic projection.* Although 3-D projections provide a readily identifiable visual image of an object, multiview projections are ideal for showing the details of an object. Dimensions can be shown easily and most features remain undistorted in multiview projections. Figure 3.6 shows a part and the front, top and side orthographic views of the part.

Model of drawing

Figure 3.6. Multi-view drawing

A multiview drawing is a collection of *flat* 2-D drawings that work together to give you an accurate representation of the overall object. With a pictorial drawing, all thee dimension of the object are represented in a single view. Enough views are generated to capture all the important features of the object.

Given their advantages, why are multiview drawings not always used? For one thing, there are the multiple views, rather than a single view, to be drawn. These views must be coordinated with one another to represent the object properly. You have to carefully visualize the views as you sketch them, and so does the person viewing them. The choice between multi-views and pictorials is often one of exact representation of features versus ease of sketching and viewing.

Orienting and selecting the front view when creating a multiview drawing of a design, the selection and orientation of the front view is an important first step. The front view is chosen as the most descriptive of the object. In addition, the object must be properly oriented in the view. The orientation of the object is based on its function. An orthographic projection is most easily thought of as a collection of views of different sides of an object front, top, side, and so forth.

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3.3. PROJECTION VIEWS

The projection view is an orthographic projection from a general view or from an existing view. Projection views follow normal lines of projection according to conventional drafting standards. As an example, a projection view is used to create right-side view off an existing front view. Projection views become child views of the view from which they are projected.

Auxiliary Views are used to project a view when normal lines of projection will not work. They are used to show the true size of a surface that cannot be shown from one of the six primary views. Auxiliary views are projected from a selected edge or axis.

Detailed Views. Often, features are too small to describe fully with a standard projection view. In such a case, it is common practice to enlarge portions of a drawing to allow for more accurate detailing.

Revolved Views are used to show the cross section of a part or feature. A cross section is required and can be retrieved or constructed from within the Revolve option. A revolved view can be either a full view or a partial view. In addition to view types such as general, projection, and auxiliary, drawing mode provides the option of controlling the visibility of selected portions of a view. The following view visibility options are available:

Half Views. Often, it is not necessary to show an entire model in a view. A good example is a symmetrical object. Half view removes the portion of a model on one side of a selected datum plane or planar surface. Half views can be used with general, projection, and auxiliary views only.

Partial Views. It is not necessary to document an entire view when only a small portion of a feature needs to be detailed. The partial view option allows a selected small portion of a view to be created. The area to be revealed is enclosed in a sketched spline. Partial views can be used with general, projection, and auxiliary views only.

Broken Views. As with partial and half views, in many views, it is not necessary to show the entire ends object. Broken views are used often with long, consistent cross sections. With a broken view, multiple horizontal or vertical breaks can be used if necessary.

Single-Surface Views is a projection of an individual part surface. They may be used with any view type except detailed and revolved. When creating a single-surface view, only the selected surface is revealed.

3.4. SKETCHING 2-D GEOMETRY

Two-dimensional sketching is accomplished on a *plane* in 3-D space. Most modern software has a means of helping you align things properly as you sketch so that your final shape looks "close" to what you desire. Sometimes this means that if you sketch a line close to vertical, then the software will automatically "force" it to the vertical position. Other times this means that a grid is included in the sketching area to help you align things as you sketch. After you have finished your sketch, you can apply constraints to achieve the final desired 2-D shape.

3.4.1. Construction Lines

Construction lines have been used throughout the history of drafting. As the name implies, these lines used as aids for the purpose of constructing parts of a drawing. Construction lines are generally remove when the drawing is finished. CADD softwares provide both construction lines (xlines) and rays. Some practical uses for construction lines might include the following:

- Making geometric constructions, such as bisecting angles or finding the center of a triangle.
- Projecting features from one view to the next in an orthographic projection for multiview drawing in mechanical drafting.
- Projecting between elevations in an architectural drawing.
- Establishing the projection of a bearing wall or partition in an architectural or structural layout.
- Creating temporary intersections for the use of object snaps.

Construction lines should be placed on a layer and in a color that clearly represents drawing development. In practice **red construction lines** might be drawn on a CONSTRUCTION layer. When the drawing is completed, the CONSTRUCTION layer may be frozen or turned off, because the con struction lines are no longer needed. Construction lines are usually not needed on the final plot. However, in some cases, they may be desirable on a check plot to help the checker determine how certain drawing fea tures were established.

Drawing Construction Lines between Two Points
The default construction line asks for two points. Look at the structural drawing example in Figure 3.7 which uses construction lines to establish the location of a gusset from the corners of an existing gusset using the following command sequence in AutoCAD:

Command: **XLINE** ⏎
Specify a point or [HorNer/Ang/Bisectloffset]: *<pick point 1>*
Specify through point: *<pick point 2>*
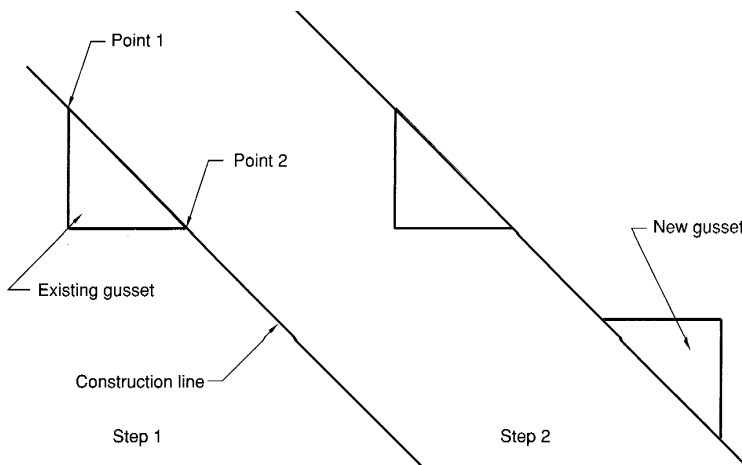Specify through point: ⏎
Command:

Figure 3.7. Drawing a construction line between two points

Drawing Horizontal and Vertical Construction Lines
Use the Horizontal option to draw a horizontal construction line from one point or the Vertical option to draw a vertical construction line from one point. Figures 3.8 shows the vertical projection to find the top and right side views from the front view of a mechanical drawing. For example in AutoCAD, this is the command sequence for drawing the horizontal construction lines :

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```
Command: XLINE ⏎
Specify a point or [HorNer/Ang/Bisectloffset]: V ⏎
Specify through point: <pick point 1>
Specify through point: <pick point 2>
Specify through point: <pick point 3>
Specify through point: ⏎
Command:
```

Point 2
Point 1
Construction lines
Point 3
Step 1: Draw construction lines from front view

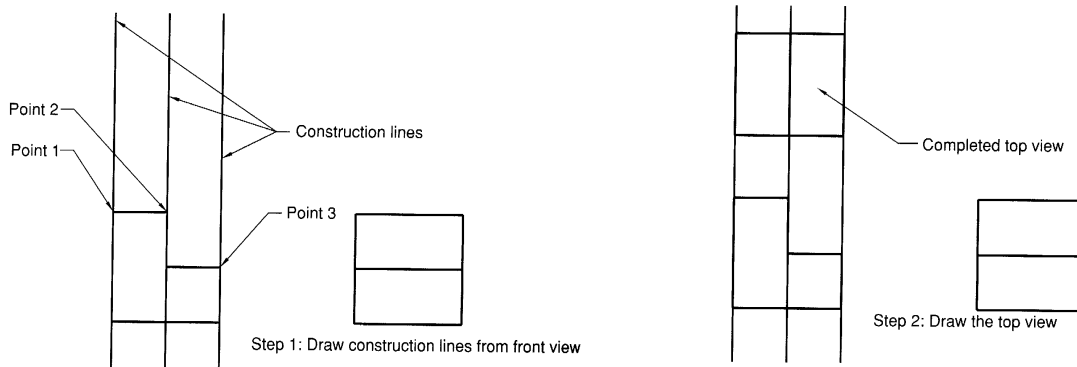Completed top view
Step 2: Draw the top view

Figure 3.8. Drawing a construction line with Vertical option

3.4.2. View Projection

You can project information from the top view to the side view and vice versa by using a 45 degree milter line. You can draw the miter line anywhere above the side view and to the right of the top view, but it is often drawn from the top right corner of the front view, as shown in Figure 3.9.
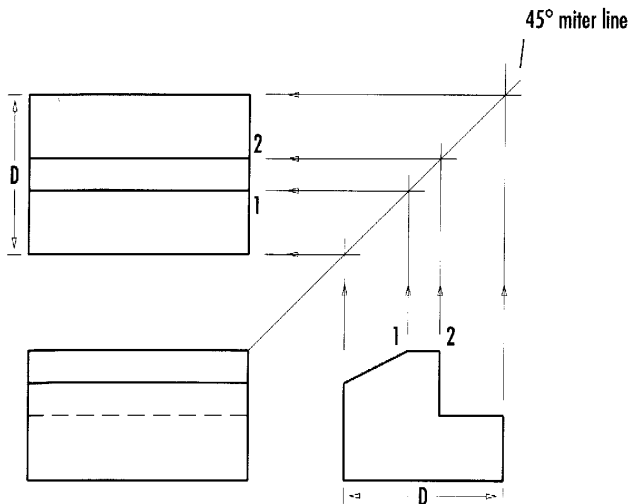
45° miter line

2
D
1

1 2

D

Figure 3.9. View projection

To project information from the side view to the top view, you would draw vertical projection lines from the points in the side view so that they intersect the milter line. In Figure 3.9 points 1 and 2 are projected. Then you would project horizontal lines from the intersection of the vertical lines and the miter line across the top view. You will draw a 45 degree line, starting where the front edge of the top view and the front edge of the side view would intersect.

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3.4.3. Hidden Lines

You use hidden lines to represent the lines that are not visible in the side view. Remember, each view is a view of the entire object drawn from that line of sight. A hidden line in the drawing represents one of three things :
   a) an intersection of two surfaces that is behind another surface and therefore not visible
   b) the edge view of a hidden surface
   c) the outer edge of a curved surface that is hidden.

You should follow at least three general practices when drawing hidden lines to help prevent confusion and to make the drawing easier to read.
   a) clearly show intersections using intersecting line segments
   b) clearly show corners, using intersecting line segments
   c) leave a noticeable gap between aligned continuous lines and hidden lines

Hidden lines are usually drawn in a different color that the one used for the continuous object lines. This practice helps distinguish the different types of lines and makes them easier to interpret.

You will create a hidden line in the side view of your drawing as shown in Figure 3.10a to represent the bottom surface of the slot. You will draw a horizontal line from the bottom edge of the slot in the front view into the side view.

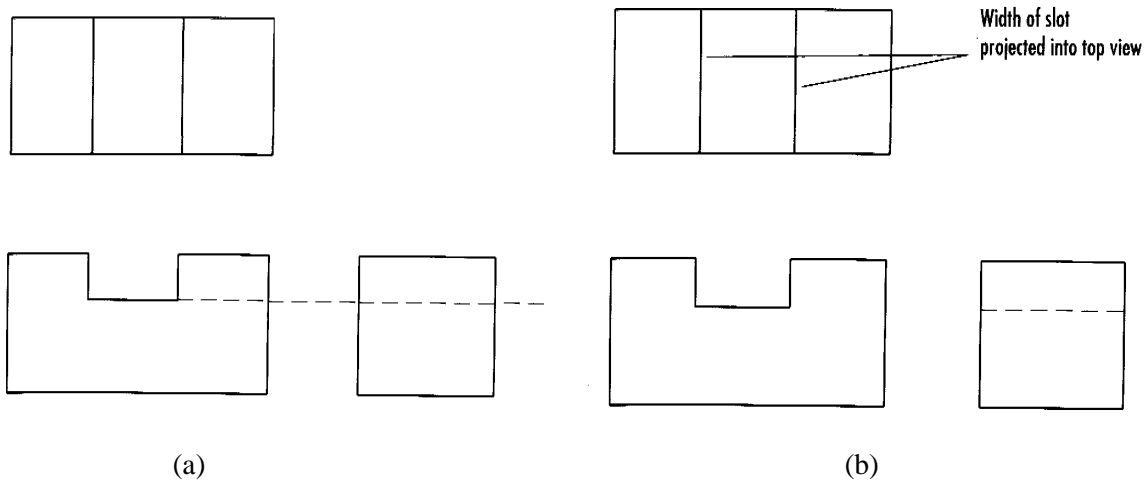(a)   (b)

Figure 3.10. Hidden lines in the side view

This line will be used to project the depth of the slot to the side view and then you will trim the projection line so that only portion within the side view remains. Finally your drawing should look as shown in Figure 3.10b.

3.4.4. Centre Lines

You will draw the centerlines for the circle. Center lines for holes must be included in all views. A centermark and four lines extending beyond the four quadrant points are used to define the center point of a hole in its circular view.

Engineering drawings involve the use of two different thicknesses of lines: thick lines are used for visible lines, and thin lines are used for hidden lines, centerlines, dimension lines, section lines, and phantom

lines. In CADD software such as AutoCAD, you typically use color to tell the plotter or printer which thickness to use when printing lines.

3.4.5. Line Precedence

Different types of lines often align with each other within the same view as shown in Figure 3.11. The rule is that continuous lines take precedence over hidden lines, and hidden lines take precedence over centerlines. If you show the short end segments were a centerline would extend, be sure to leave a gap.
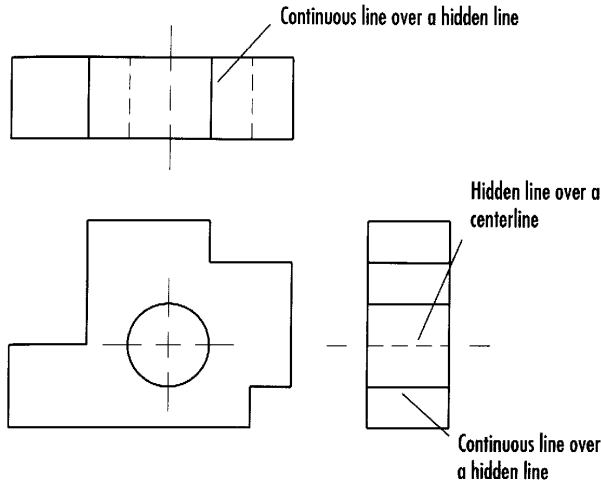

Figure 3.11. Line precedence in 2D drawing

You must decide which lines to show in your 2D orthographic views. If you draw a line over the top of another line in CADD software, both lines will be in your drawing. If you are using a plotter, both will plot, making a darker or thicker line that should be shown.

3.4.6. Adjusting Linetype Scale

The linetype scale determines the relative length of dashes in linetypes such as hidden and center lines. Setting a linetype scale ensures that the lines you draw are represented properly on the screen and when the drawing is plotted.

Figure 3.12. gives you an example of using different linetypes scales on a phantom line. You can change the global linetype scale at the keyboard using **LTSCALE** command. Making linetype scale changes in this manner alters the scale of every linetype on the drawing to match the specification you request. The command sequence looks like this.

> Command : **LTSCALE** ⏎
> Enter new linetype scale factor <1.000> : **0.5** ⏎
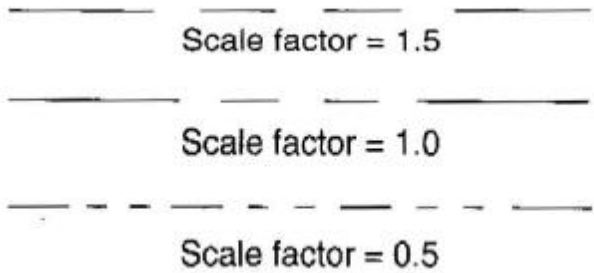> Regenerating model.
> Command :

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Figure 3.12. A comparison of linetype scale factors

Questions
1. What is the easiest way to return to the previously displayed view
2. What is the difference between Zoom All and Zoom Extents?
3. Briefly explain why layers are important?
4. Why is a good layer naming system needed?
5. What is a continuous linetype?
6. Describe two ways to make a layer current
7. What does the term ByLayer mean ?
8. What is the difference between the Display, Extents, Limits and Window Plat area options?
9. What are the advantages of using partial or full plot previews?
10. Describe two types of sketching done in engineering graphics.
11. How many primary views are possible in orthographic projection?

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