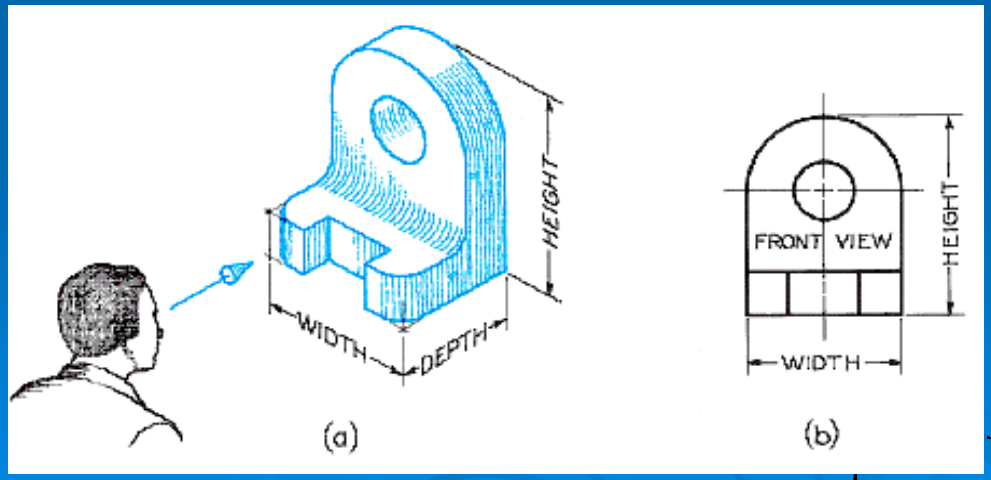
CHAPTER 5
MULTIVIEW SKETCHING AND PROJECTION

5-1 Views of Objects

The engineering design and manufacturing activities require clear complete communications among involved bodies. The most important thing among many others is the shape (i.e., geometry) of the product.

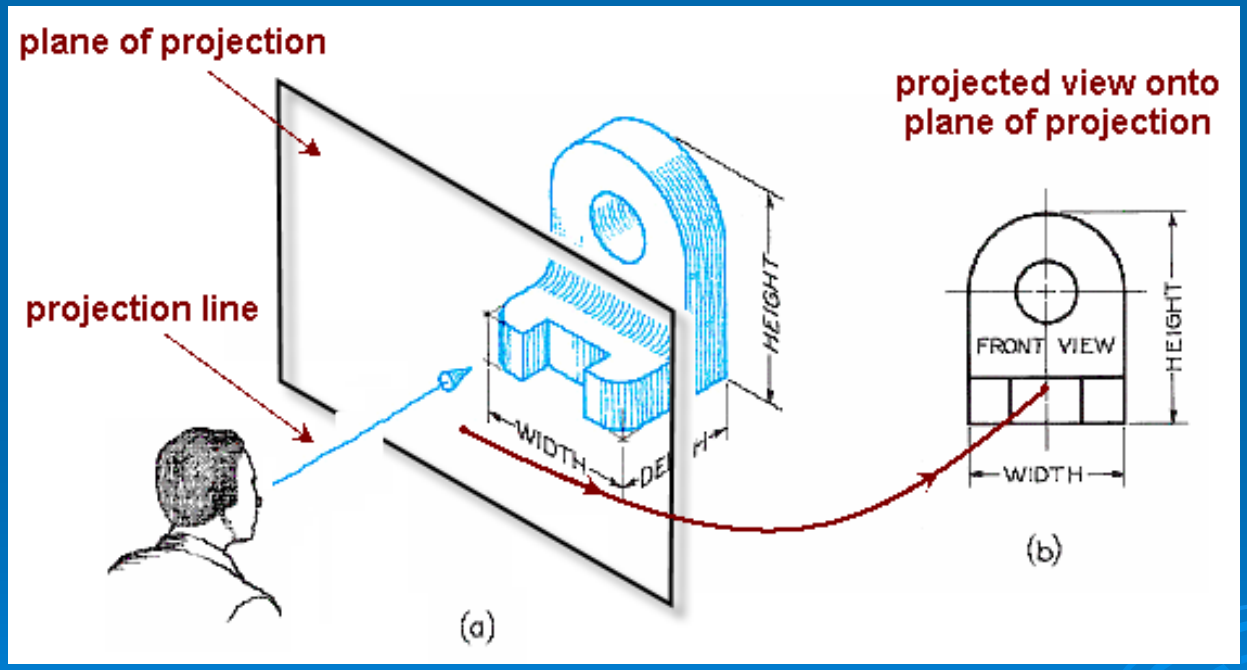
Since the product is three-dimensional and the communication should be done in two-dimensional dimension (i.e., engineering drawing), several sides of the product must be shown by projection.

The following shows one projected shape. How was it done?



The theory of projecting the product to two dimensional plane is called the principle of orthographic projection which projects the product perpendicular to the planes of projection using parallel projection lines.

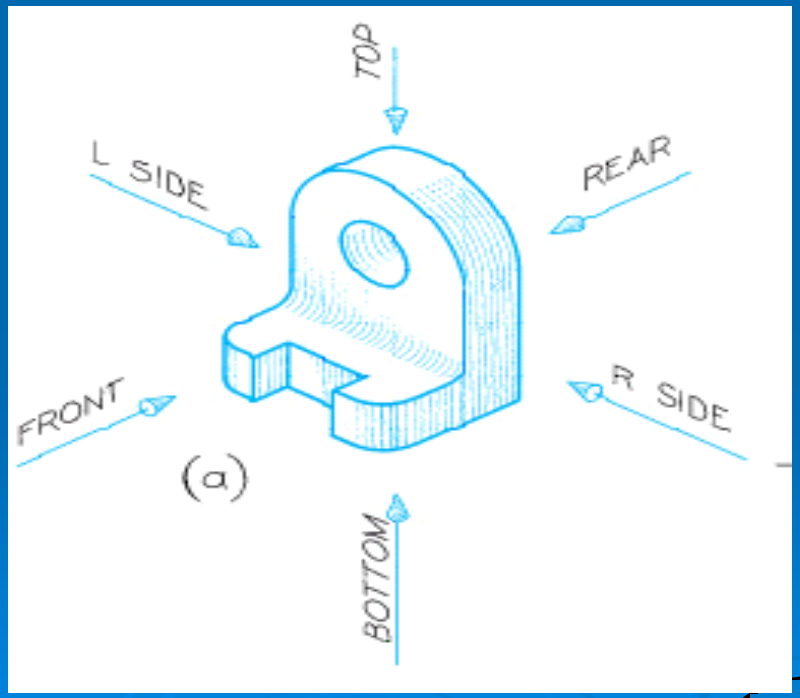
The projected shapes of the product on the planes of projection are called views.



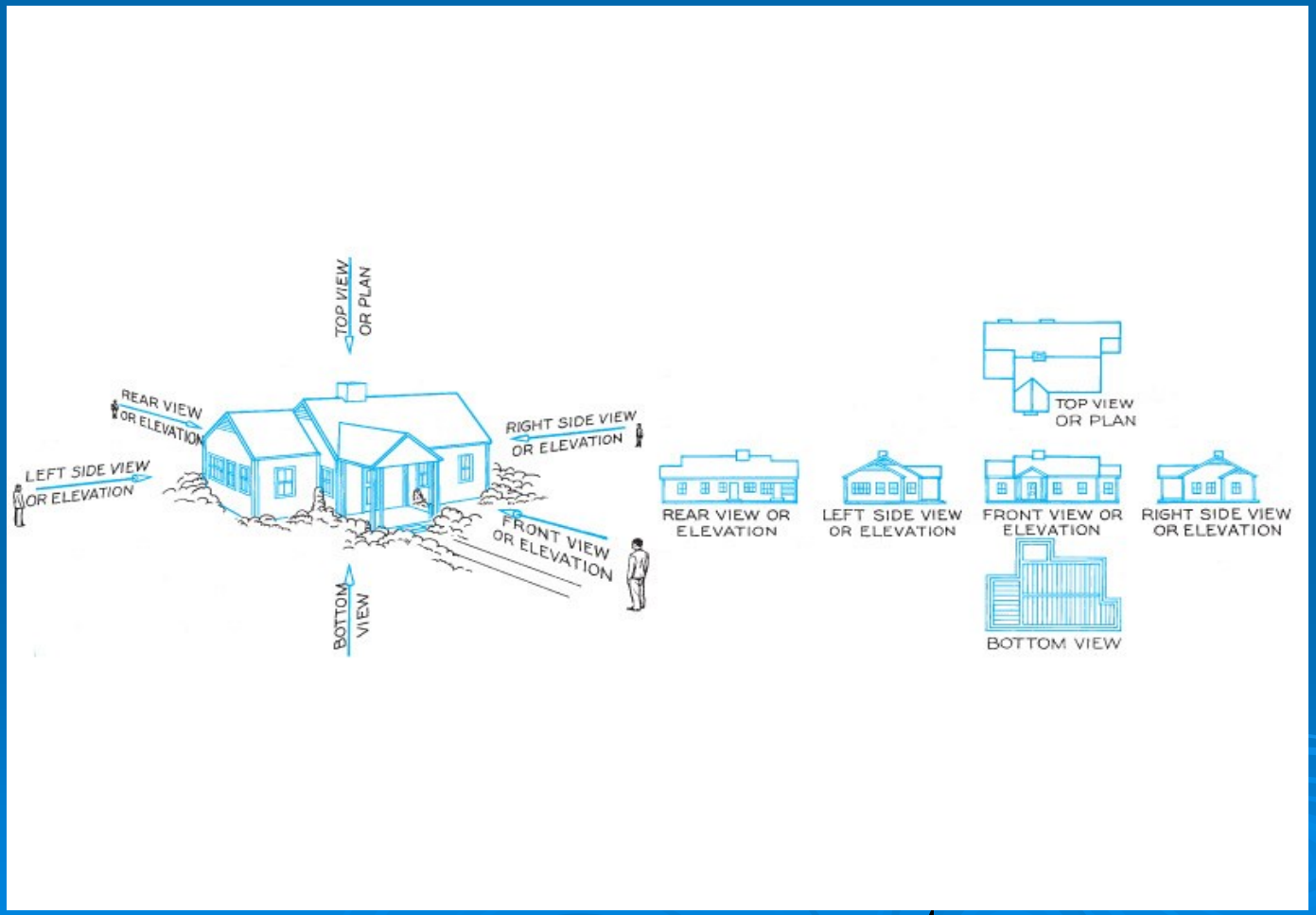
5-2 Six Principal Views

Of course, the shape of one side is not enough to describe the product completely. The number of views to describe the product completely depends on the shape of the product.

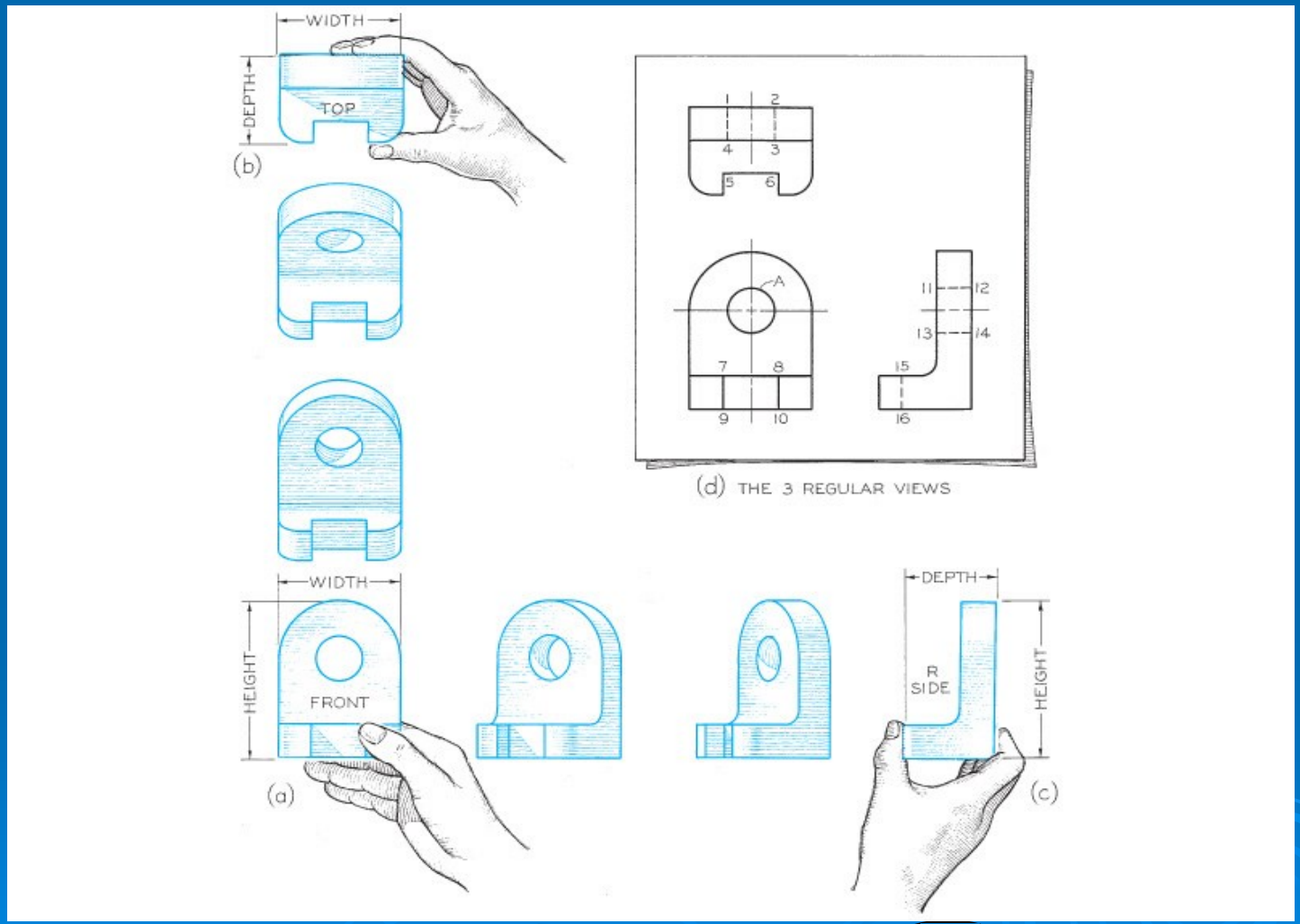
There are six principal views on six principal planes of projection.



You can think of the six views as what an observer would see by moving around an object.

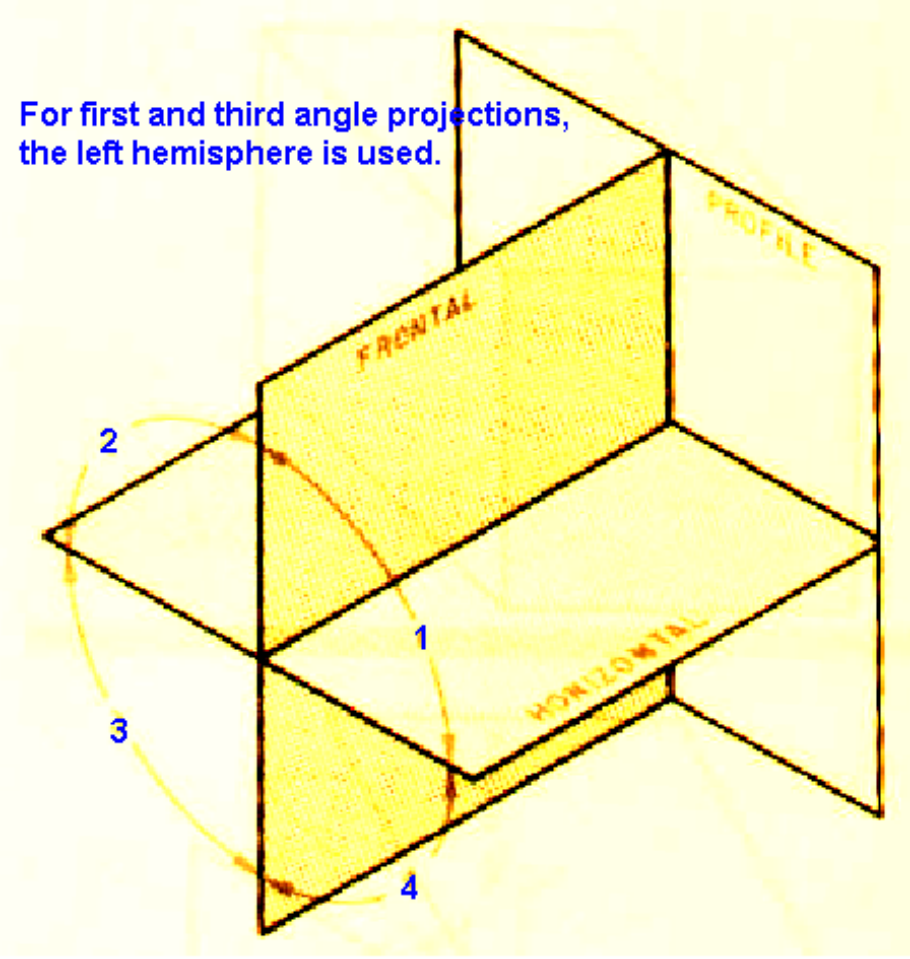


Alternatively, you can also produce different views by rotating the object.

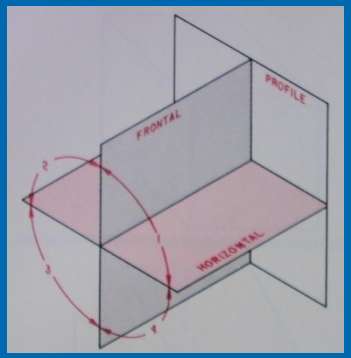


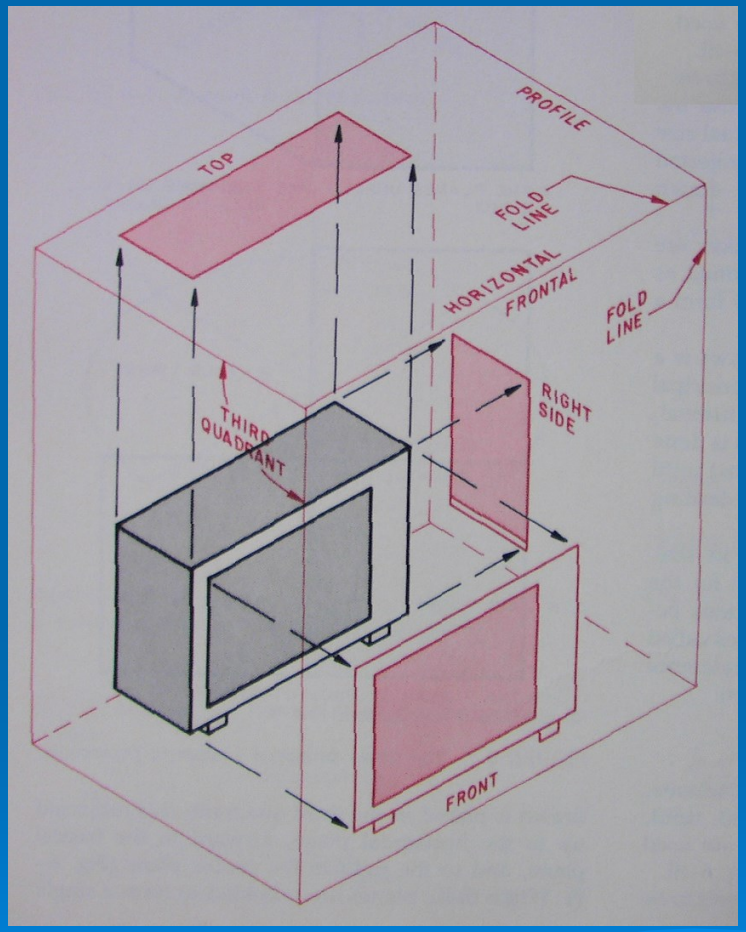
5-43 First and Third Angle Projections

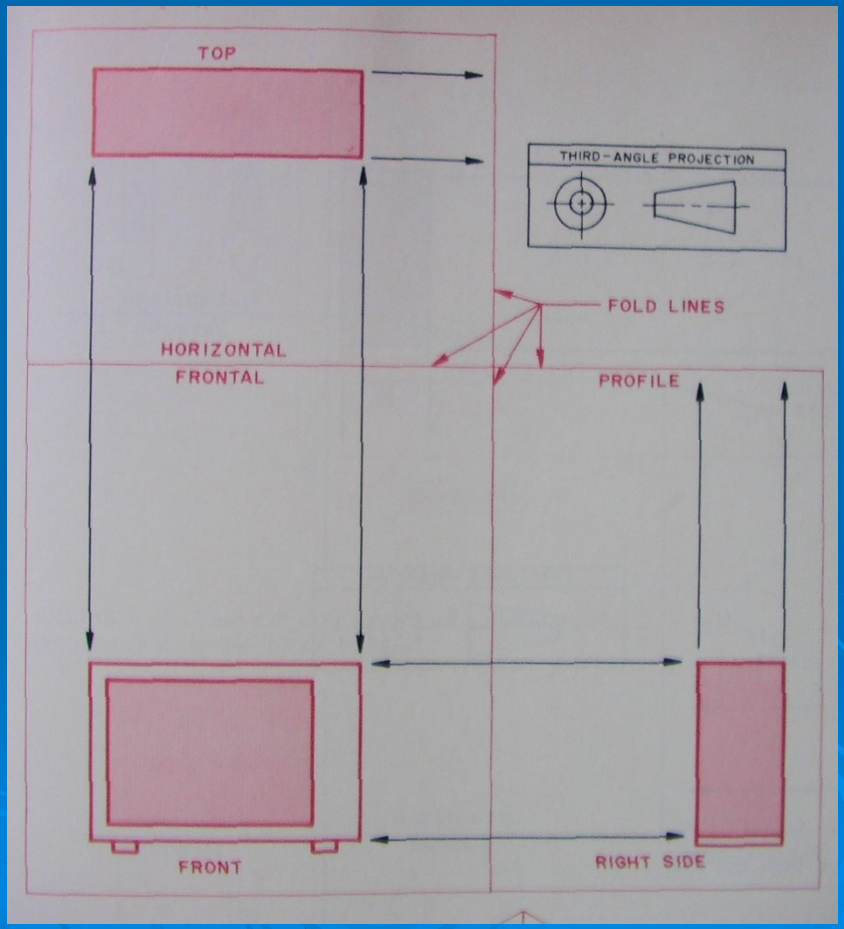
Three mutually orthogonal planes of projections form eight quadrants.



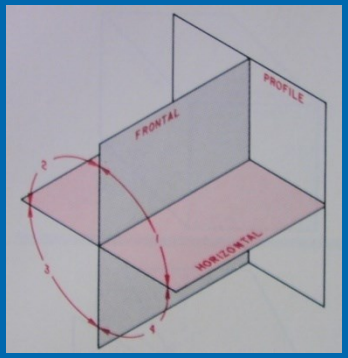
Third Angle Projection

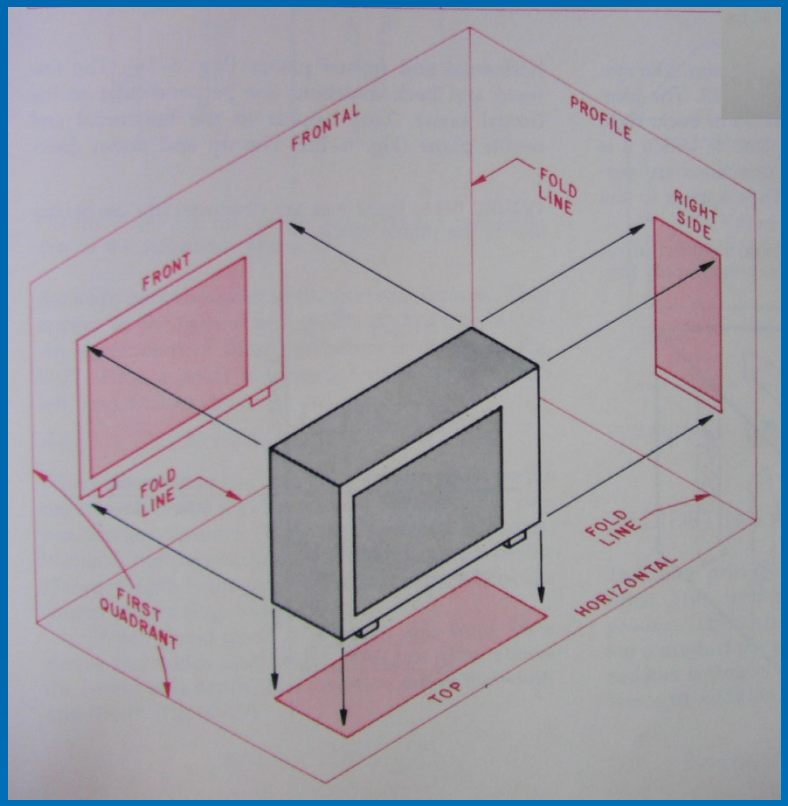


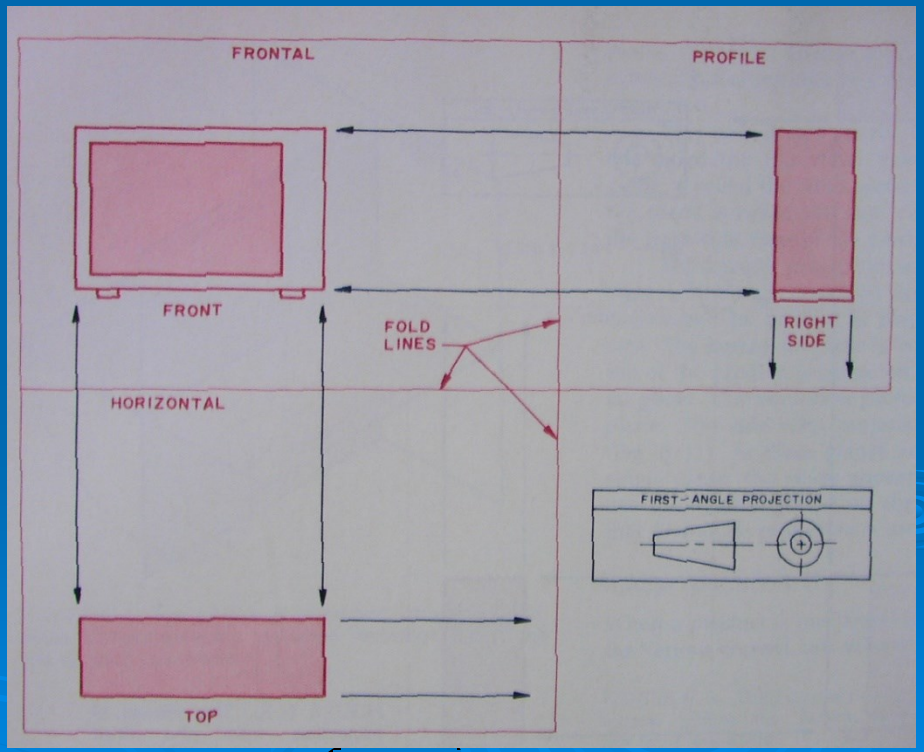




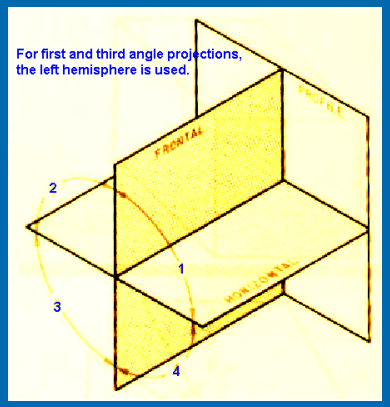
First Angle Projection

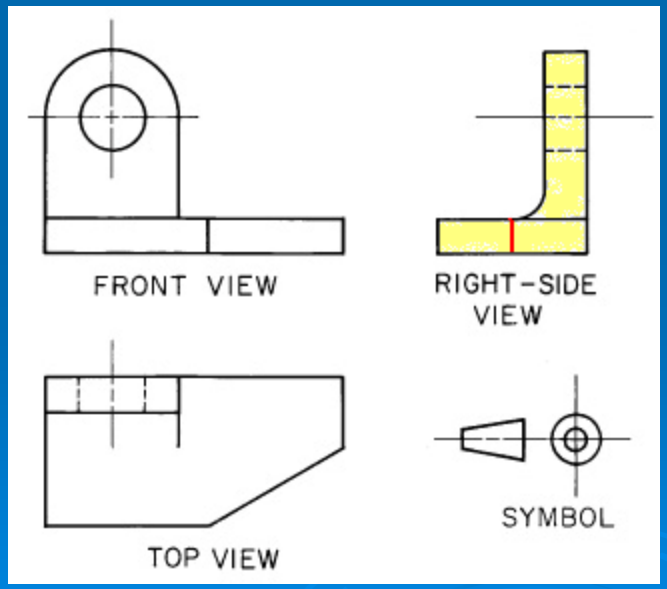


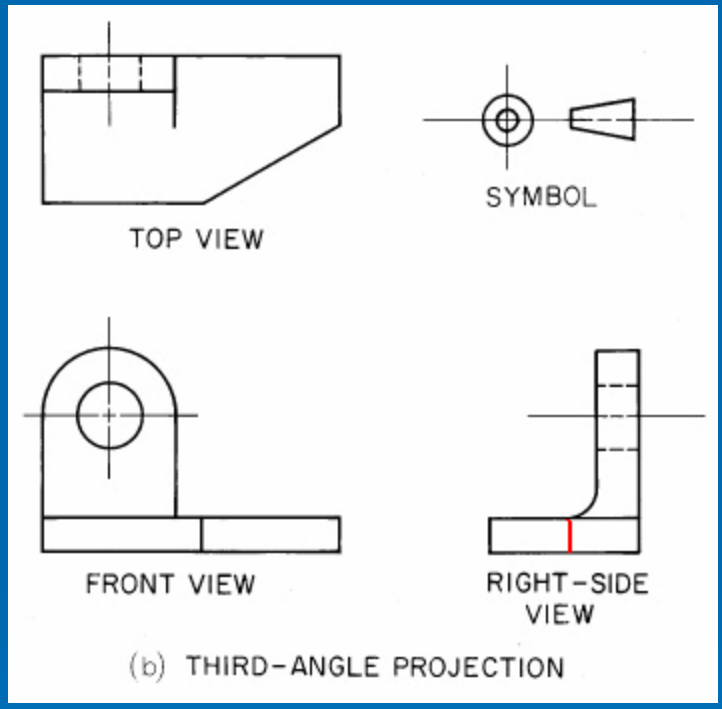




Another Example of First and Third Angle Projections

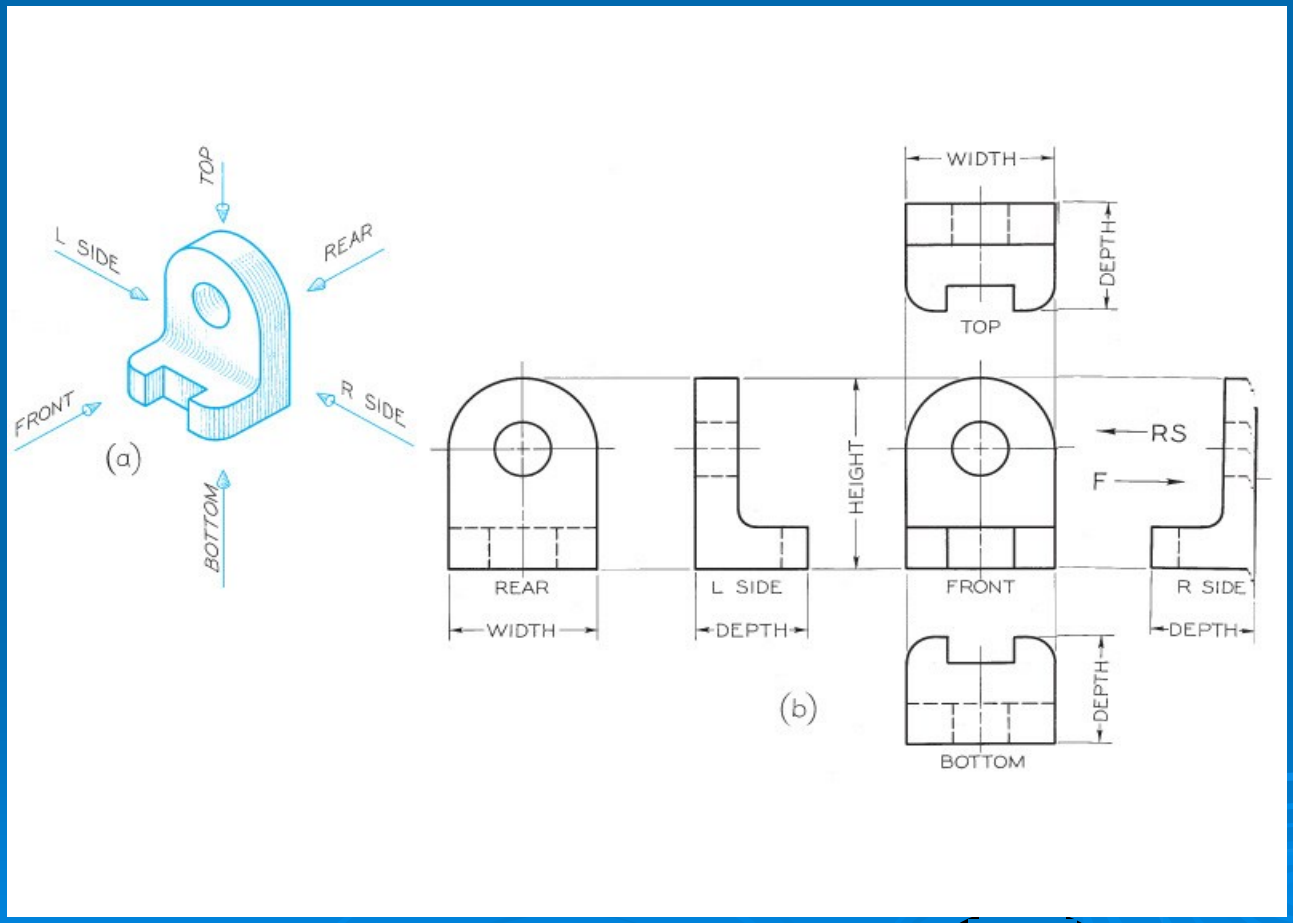


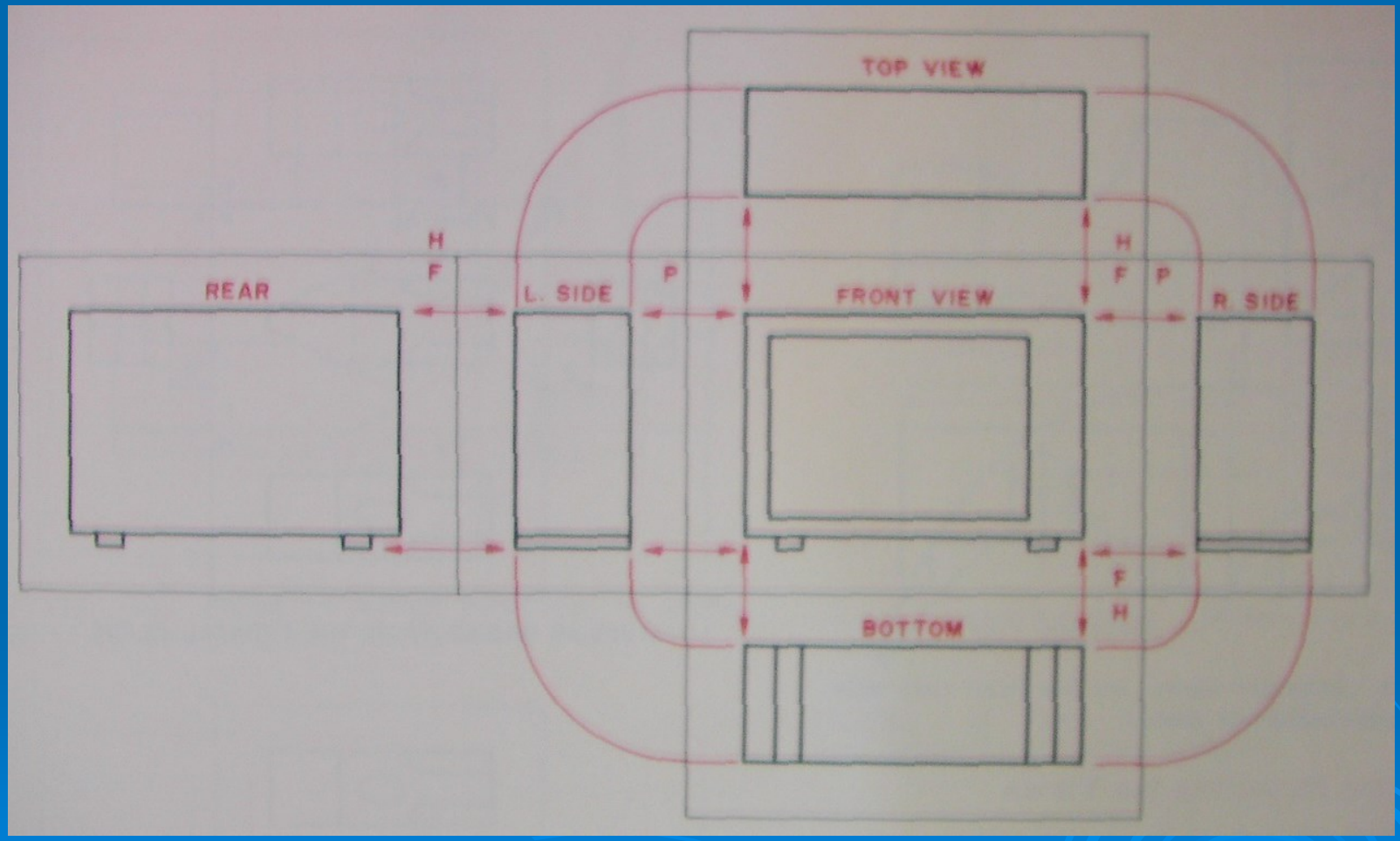




Six Principal Views

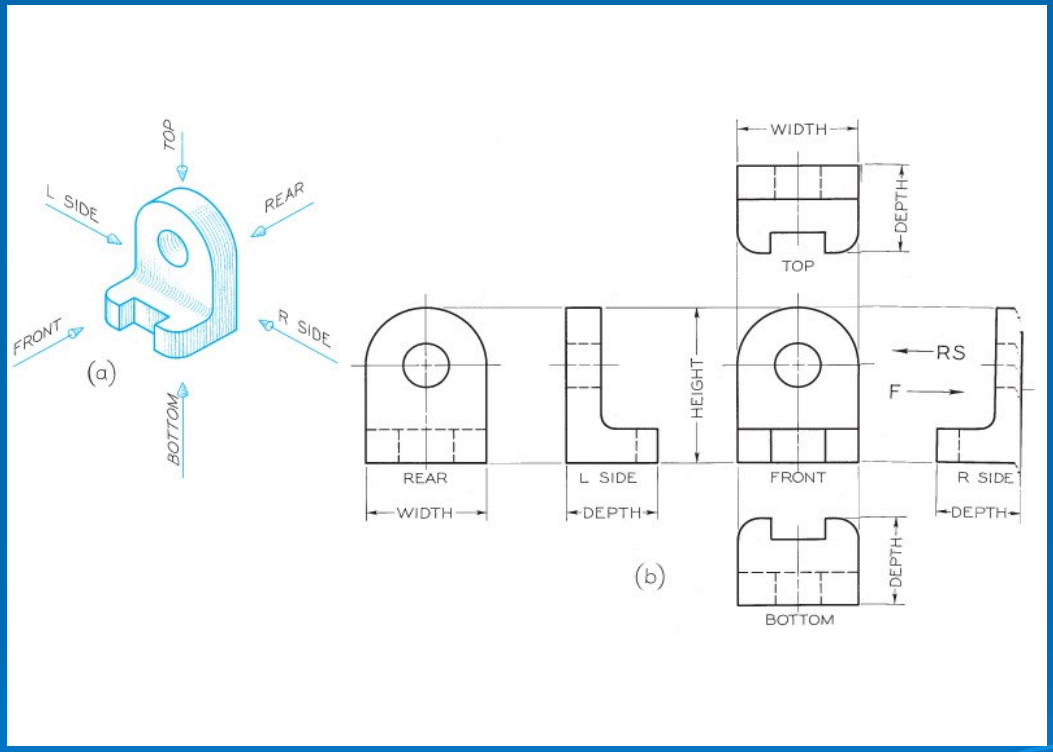
Below shows the American National Standard arrangement of multiview.




TOP VIEW
H
F
REAR
L. SIDE
P
FRONT VIEW
H
F
P
R. SIDE
F
H
BOTTOM

5-3 Principal Dimensions

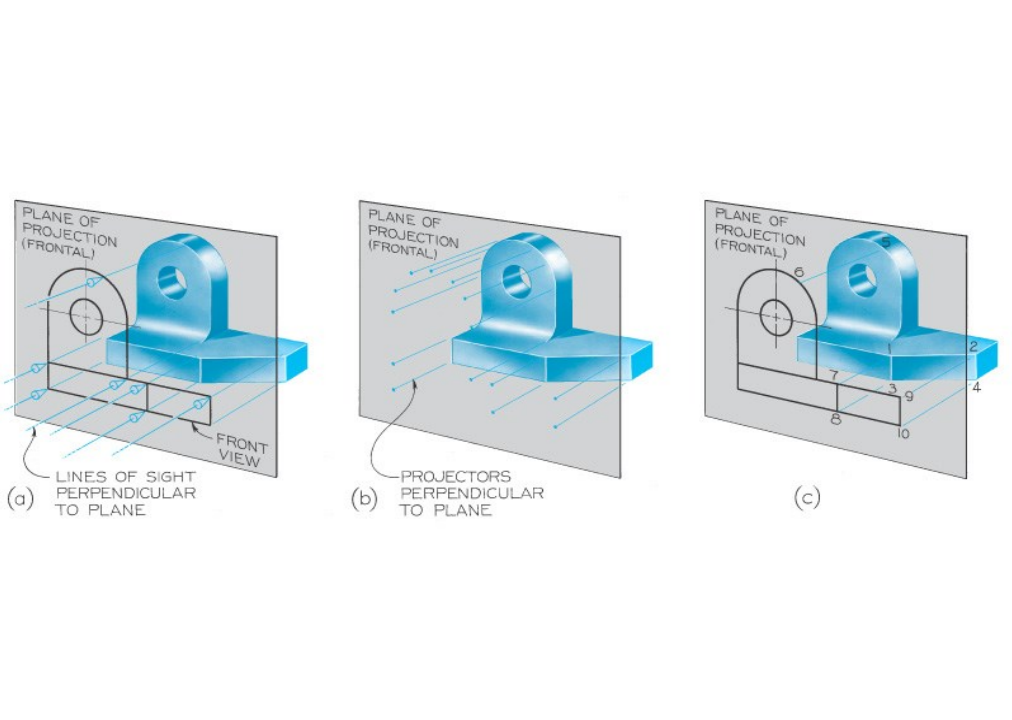
There are three principal dimensions of an object that are width, height, and depth.

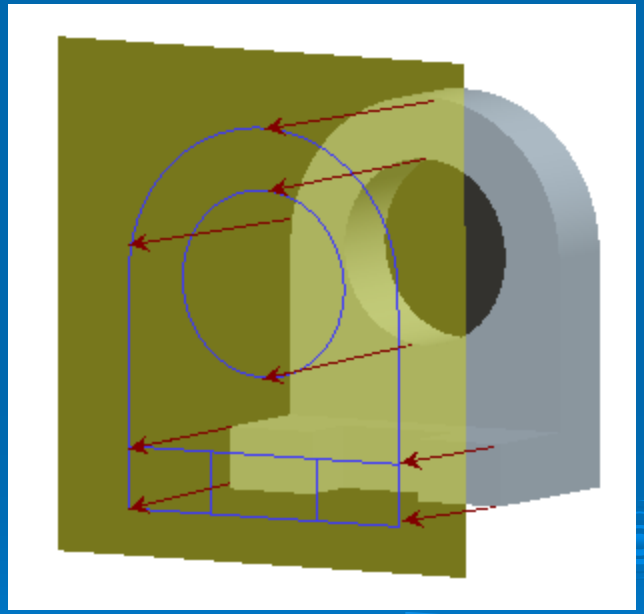


The front view shows only height and width of the object. In fact, any principal view of a 3D object shows only 2 of the 3 principal dimensions.

5-4 Projection Method

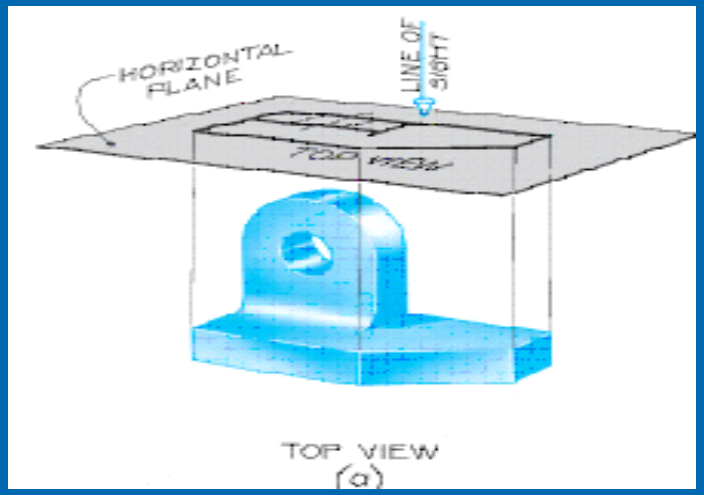
The following figure shows how to create a front view of an object. Imagine a sheet of glass parallel to the front of the object. This represents the plane of projection.

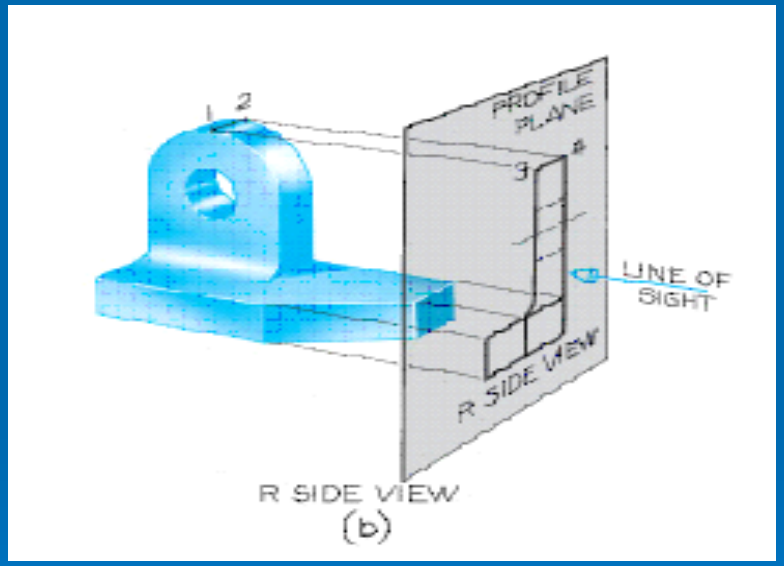




The outline (i.e., view) on the plane of projection shows how the object appears to the observer.

Similar examples of the top and side views are shown below.

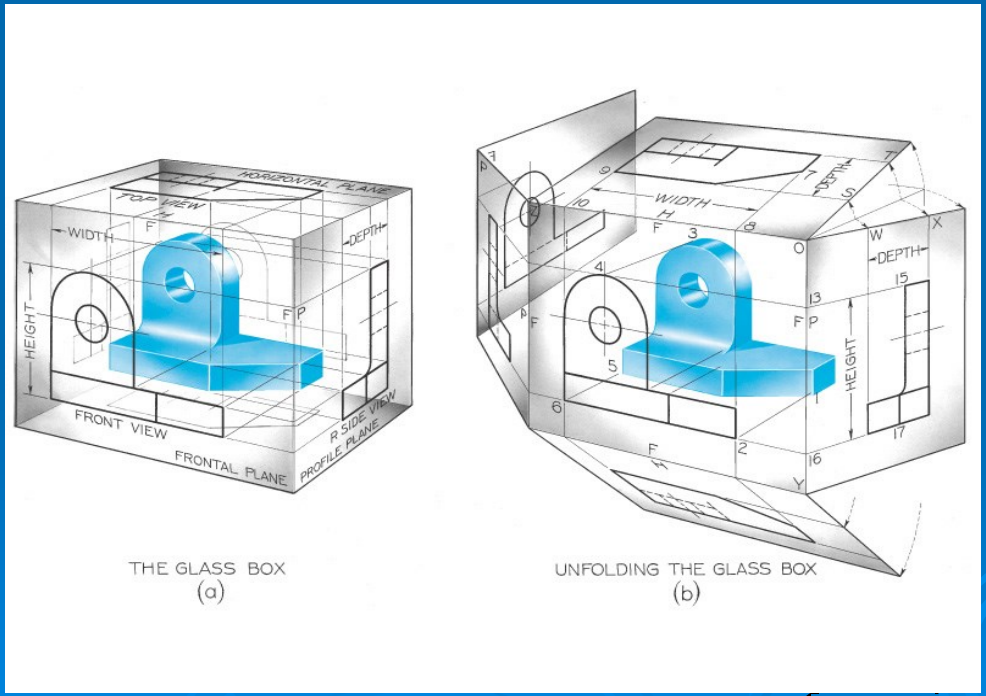




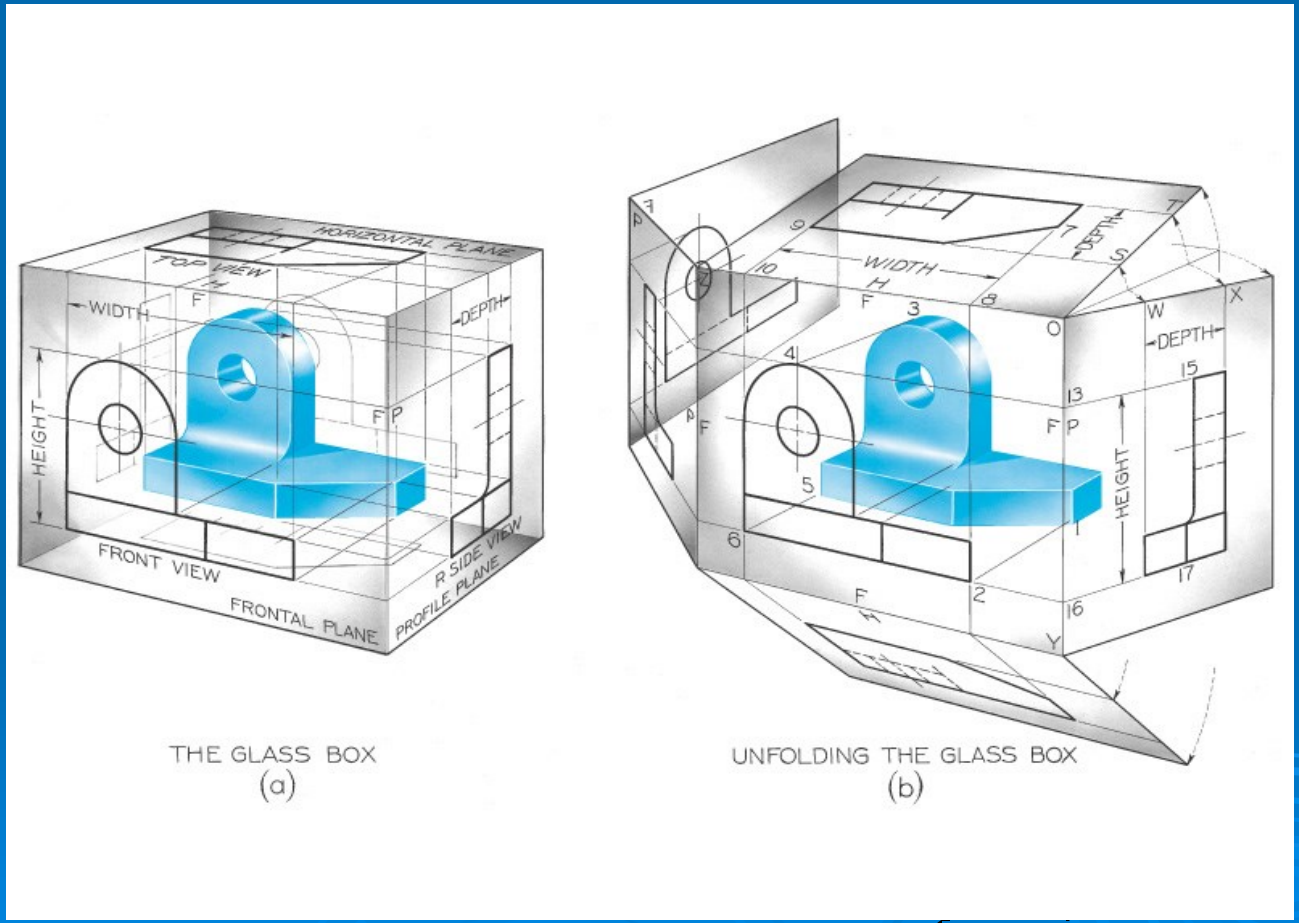
5-5 The Glass Box

If the planes of projection are placed parallel to each principal faces of the object, they would form a box, as shown on figure (a).

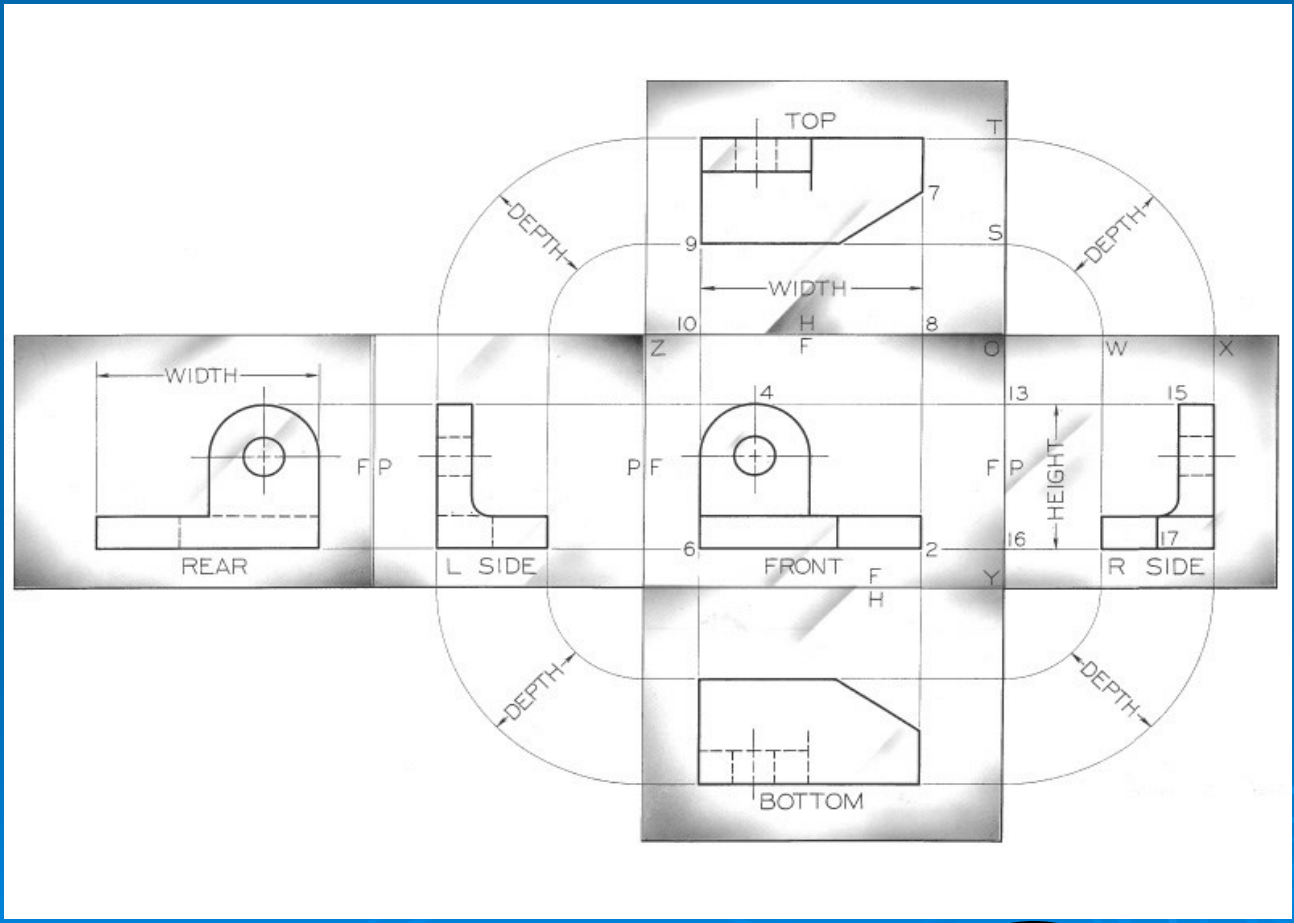
The outside observer would see standard views of the object through the sides of this imaginary glass box.



To organize the views of the 3D object on a flat sheet of paper, the six planes of the glass box are unfolded to lie flat, as shown on figure (b) relative to the frontal plane of projection.

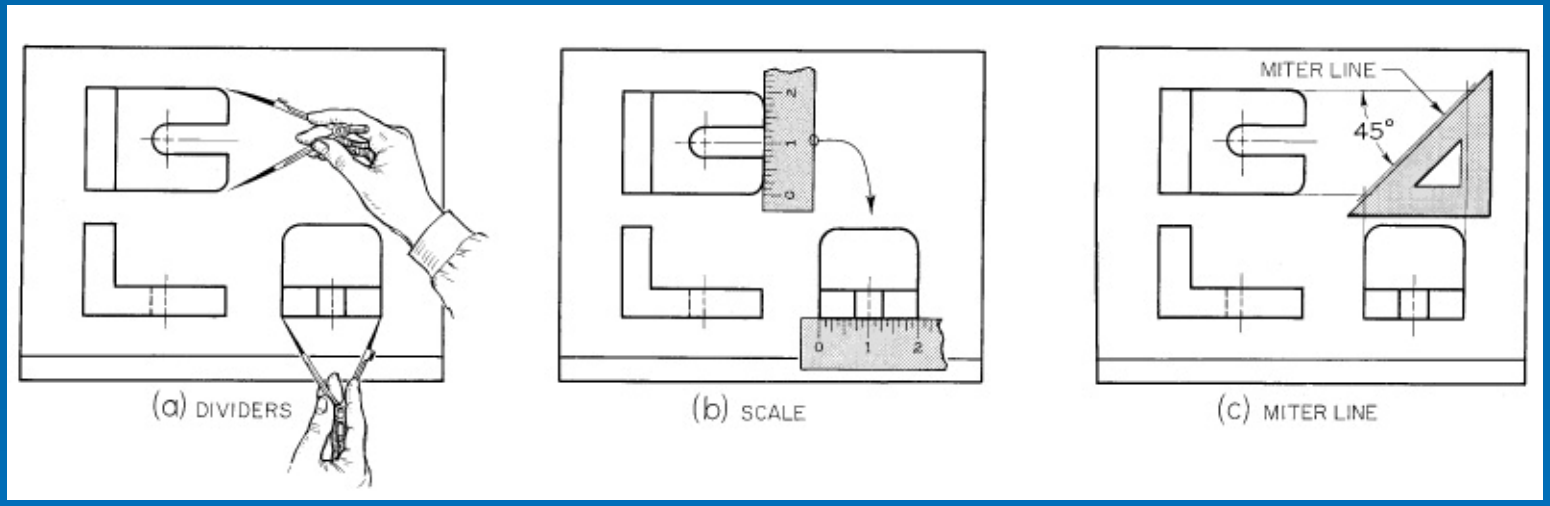


The unfolded glass box is shown below in the standard layout. Pay attention to the position of front view on frontal plane relative to others.

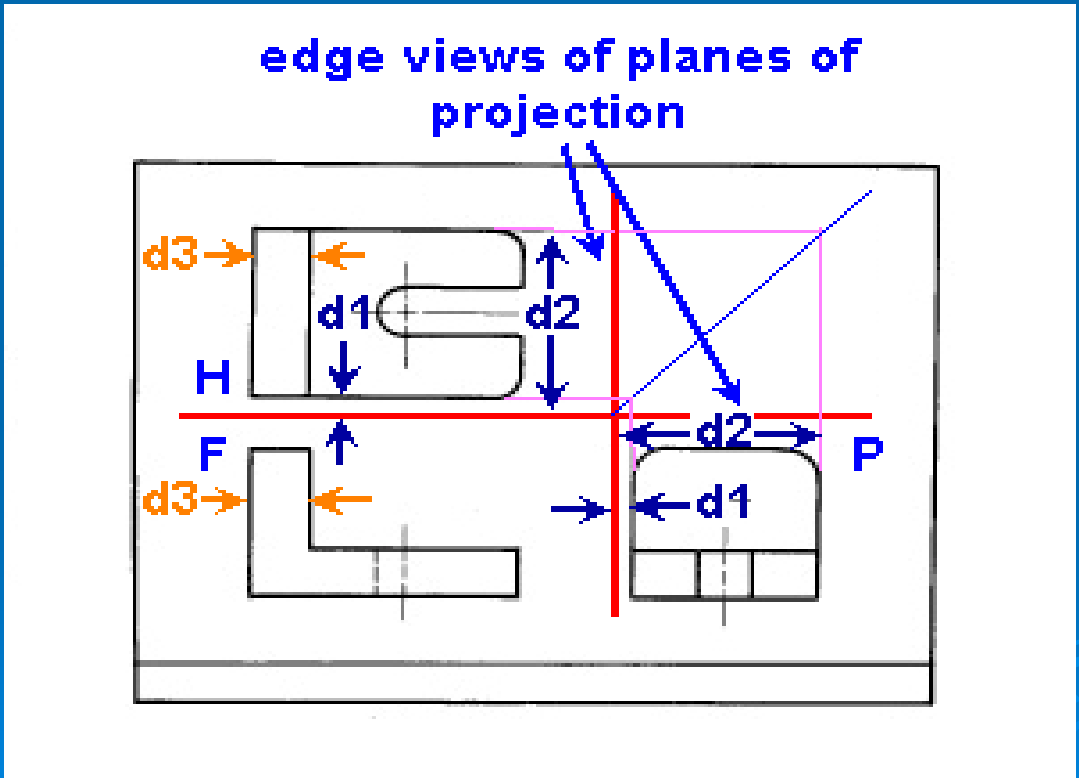


5-7 Transferring Depth Dimensions

You can transfer dimensions between the top and side views either with dividers or with a scale as shown below.

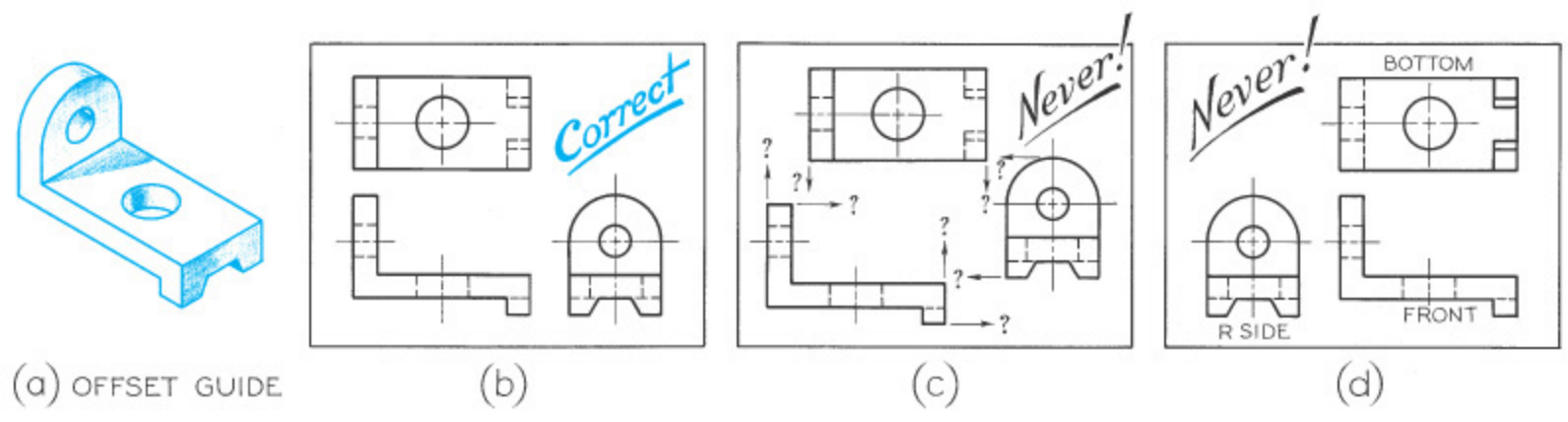


More rigorously, the views can be related by projection lines through planes of projection in edge views. Note that the planes serve as references for view positions.



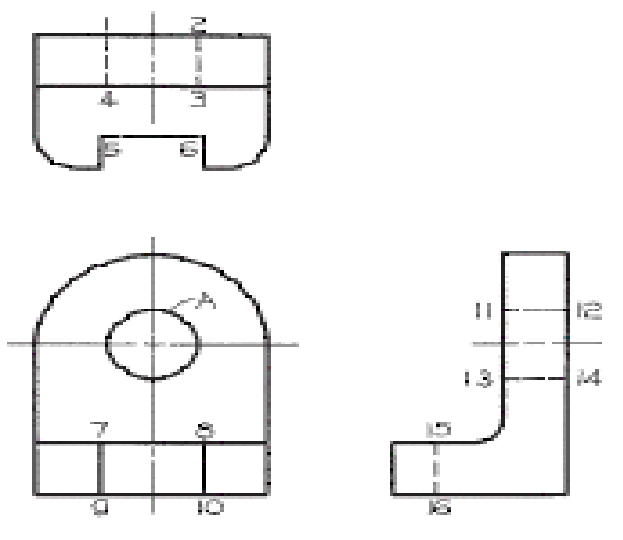
5-42 Alignment of Views

Always draw views in the standard arrangement shown in figure below to be sure that your drawing is not misinterpreted.



5-8 Necessary Views

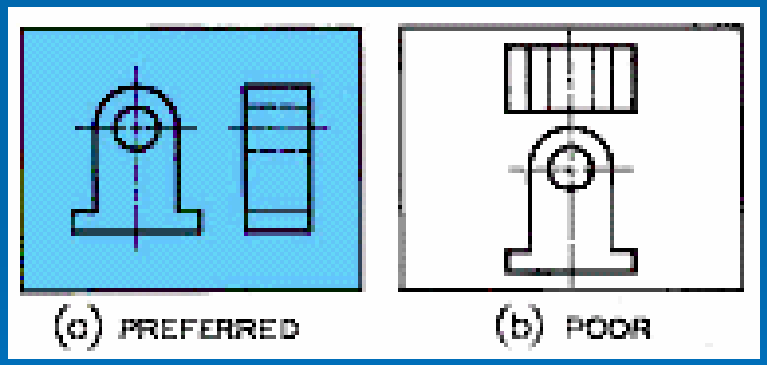
For most of the product, three principal views are good enough to describe the product. They are top, front, and right side views, arranged together as shown below.

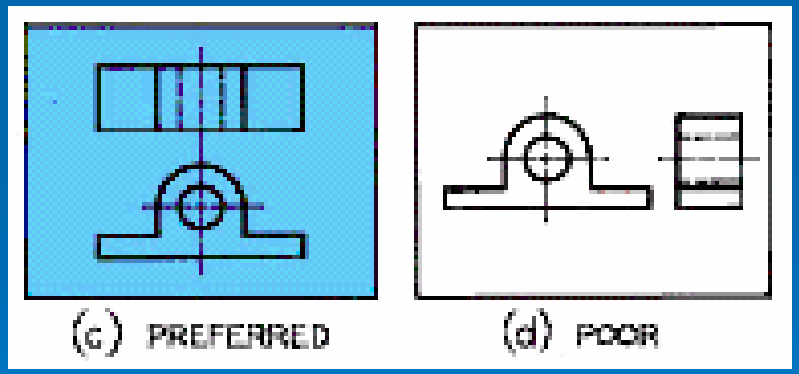


A sketch or drawing should only contain the views needed to clearly and completely describe the object. These minimally required views are referred to as the necessary views.

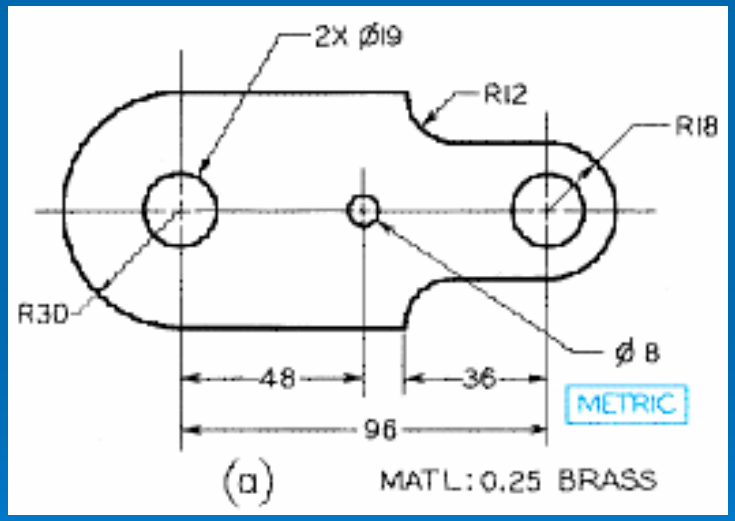
Many objects may need only 2 views to clearly describe their shape. If only 2 views are necessary and top view and right side view show the object equally well, choose a combination that fits best on your paper.

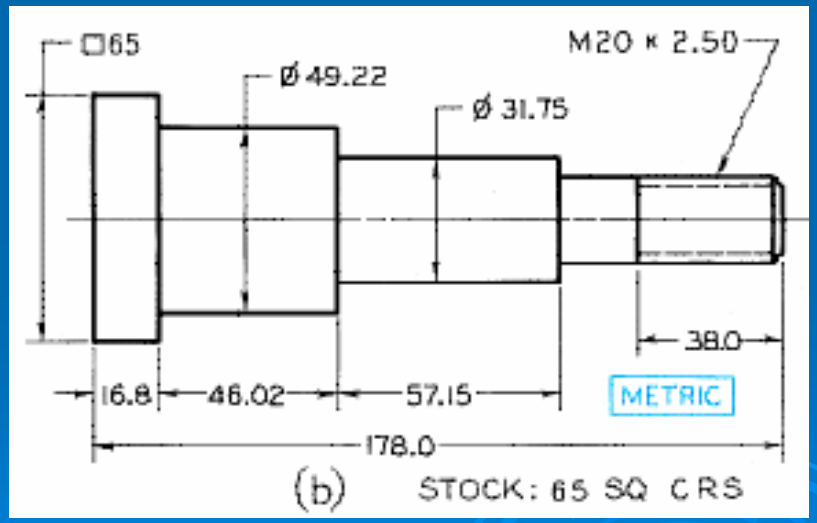
Two examples are shown below.





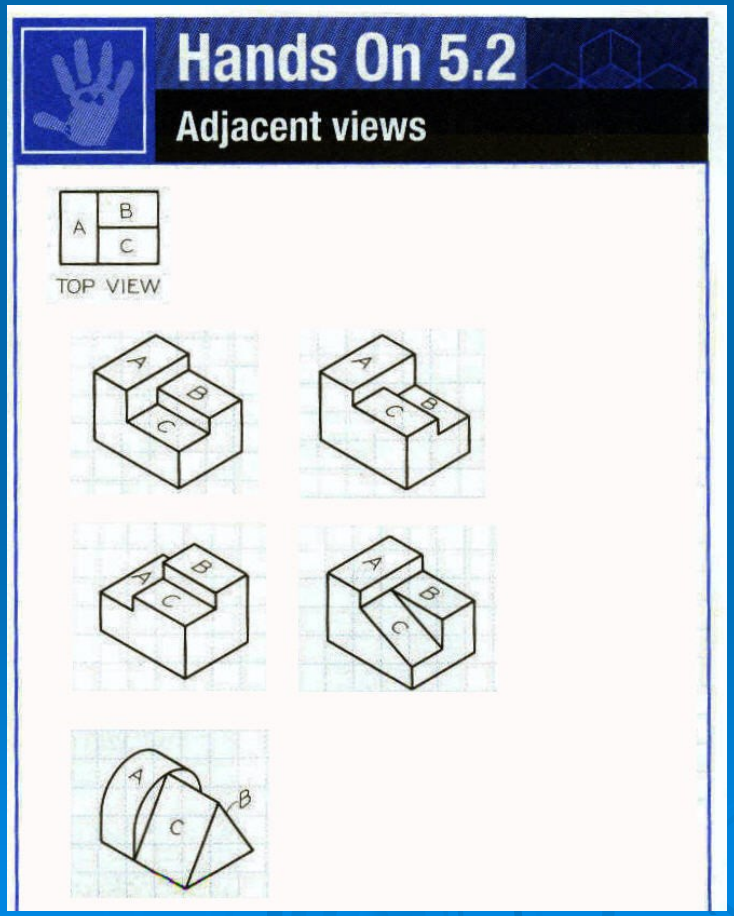
Often, a single view supplemented by a note or by lettered symbols is enough. Objects that can be shown using a single view usually have a uniform thickness as shown in figure (a) that uses a note for the thickness. The second figure is a revolved feature that also needs only one view with diameters.





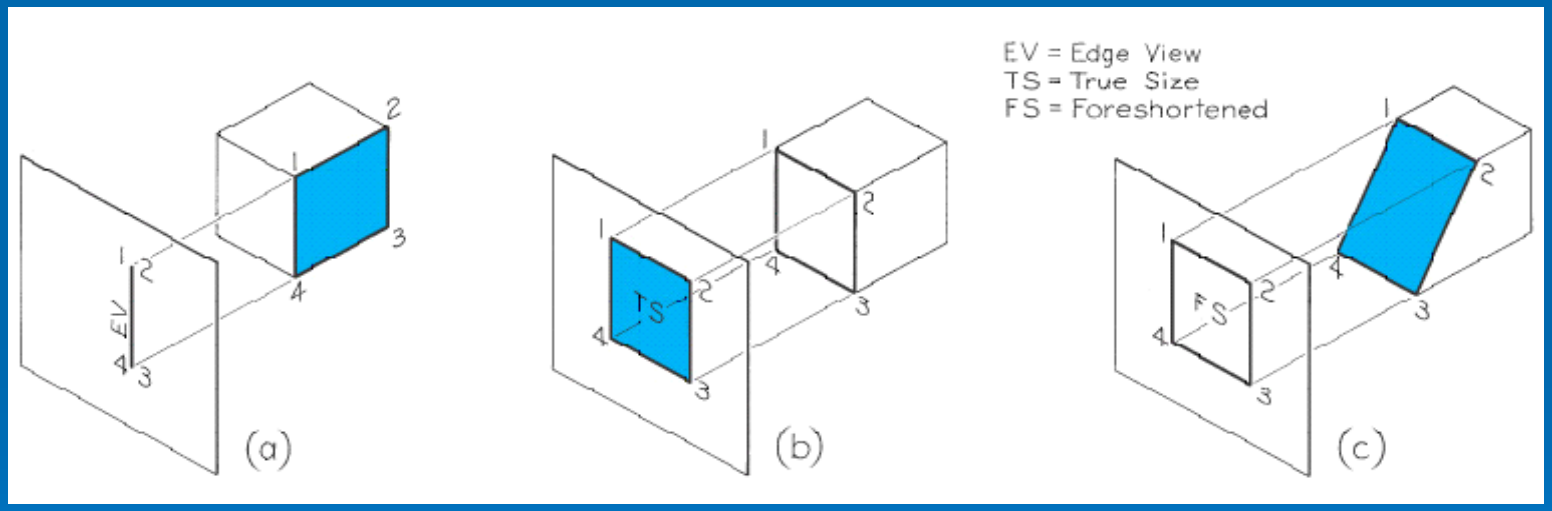
Hands-on Example

The following shows several possible shapes of the given top view. Can you find more shapes?



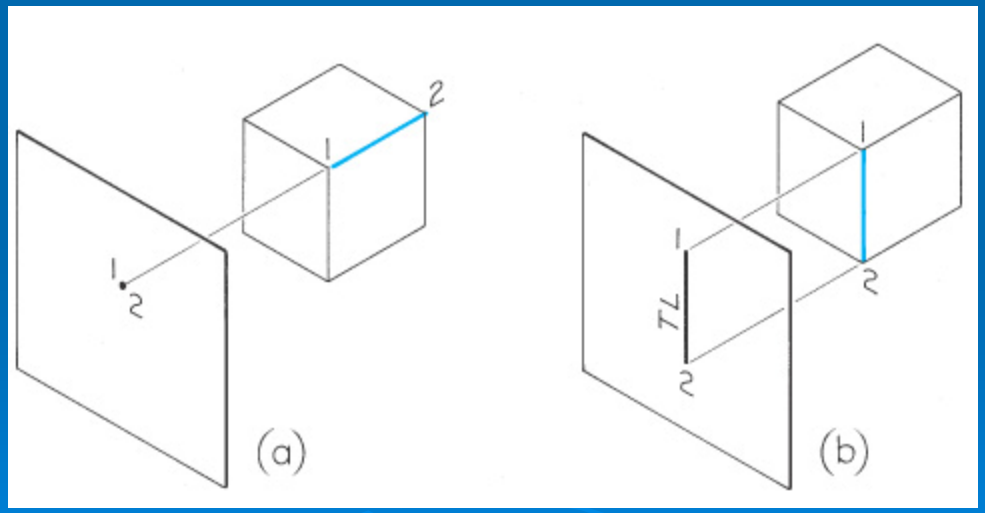
5-13-16 Surfaces

A plane that is perpendicular to a plane of projection appears as an edge (see figure a). If it is angled to the plane of projection, it appears foreshortened or smaller than its actual size (figure c). The plane appears true size (TS) only when it is projected to the parallel plane of projection.

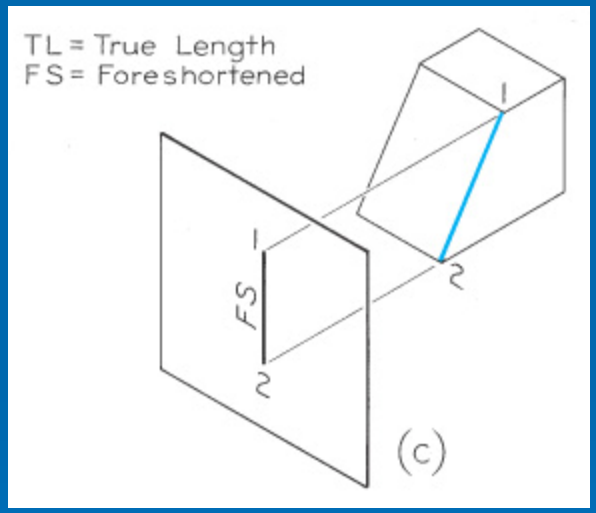


Normal edge is a line that is perpendicular to a plan of projection. It appears as a point on that plane of projection (figure a) and as a true length on adjacent planes (figure b).

Inclined edge is an edge that is parallel to the plane of projection but inclined to adjacent planes. It appears as a true length on the plane to which it is parallel and as a foreshortened line on adjacent planes (figure c).

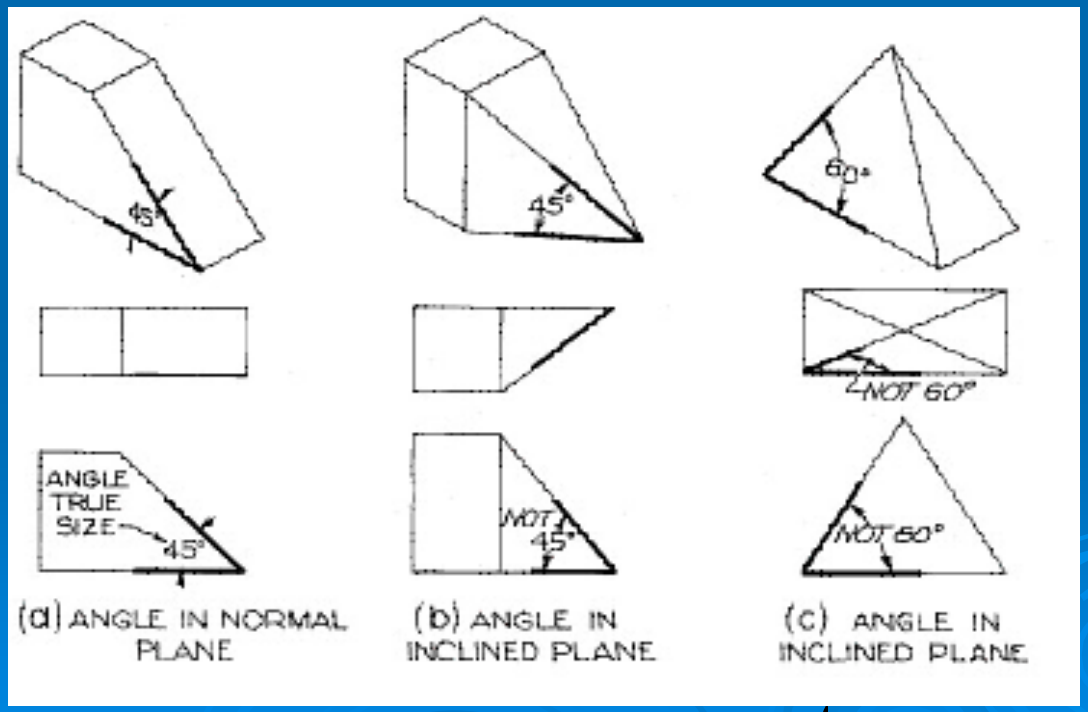


Oblique edge is an edge that is tipped to all planes of projection. Since it is not perpendicular to any projection plane, it cannot appear as a point in any standard view. Since it is not parallel to any projection plane, it cannot appear true length in any standard view, either.



5-21 Angles

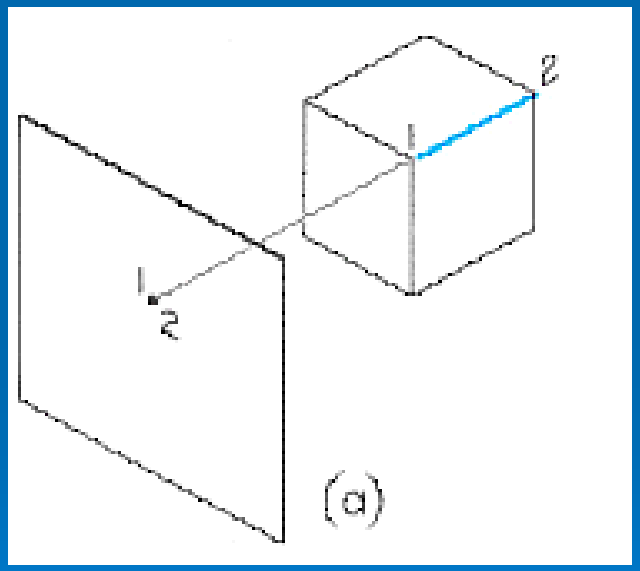
If an angle is in normal plane (i.e., parallel plane to plane of projection), the angle will be shown true size on the plane of projection to which it is parallel (figure a). If the angle is in an inclined plane, it may be projected either larger or smaller than true angle, depending on its position. Figure (b) shows that the projected angle is bigger than true angle while figure (c) smaller.



5-23 Meaning of Points

A point located in a sketch can represent two things on the object.

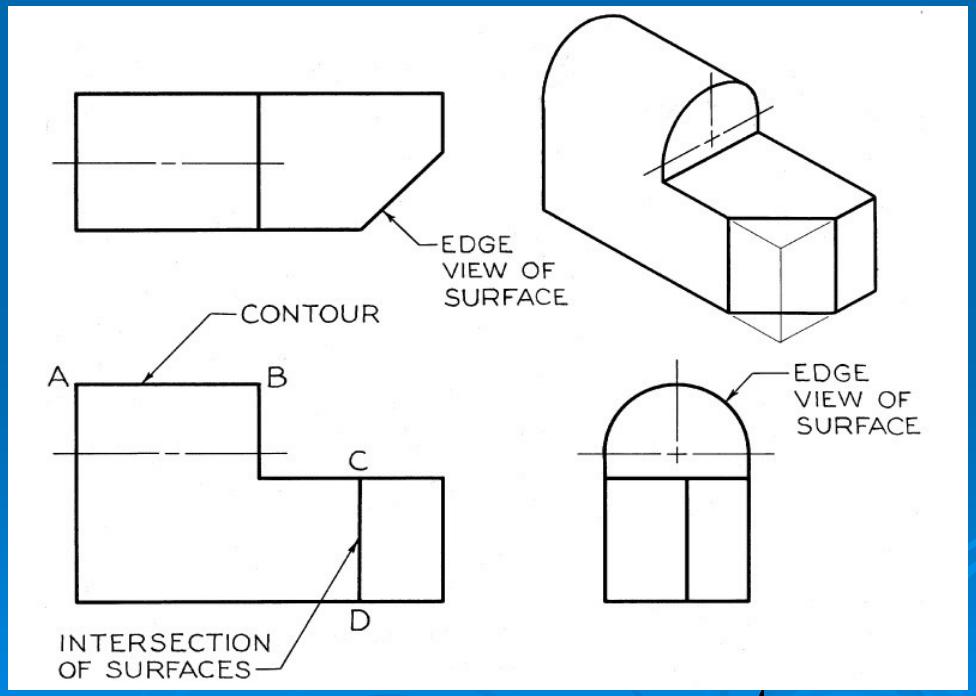
1. A vertex
2. The point view of an edge



5-24 Meaning of Lines

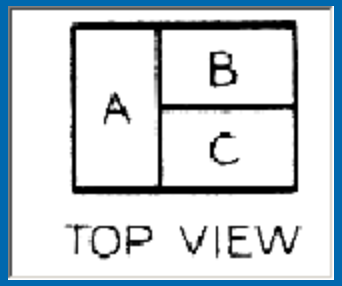
A straight visible or hidden line in a sketch has 3 possible meanings.

1. An edge (intersection between 2 surfaces)
2. The edge view of a surface
3. The limiting element of a curved surface

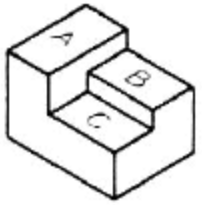


Hands On 5.2

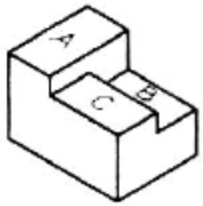
The following shows the top view of a product. Can you tell what shape the product has?



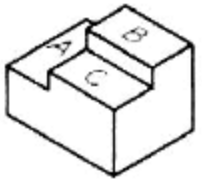
- Surface B is highest, and C and A are both lower.



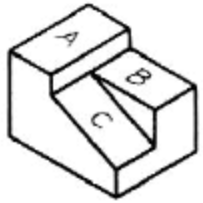
- One or more surfaces is cylindrical.



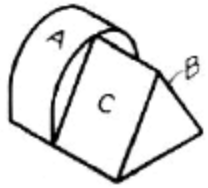
- One or more surfaces is inclined.



- Surface A is highest, and surfaces B and C are lower.

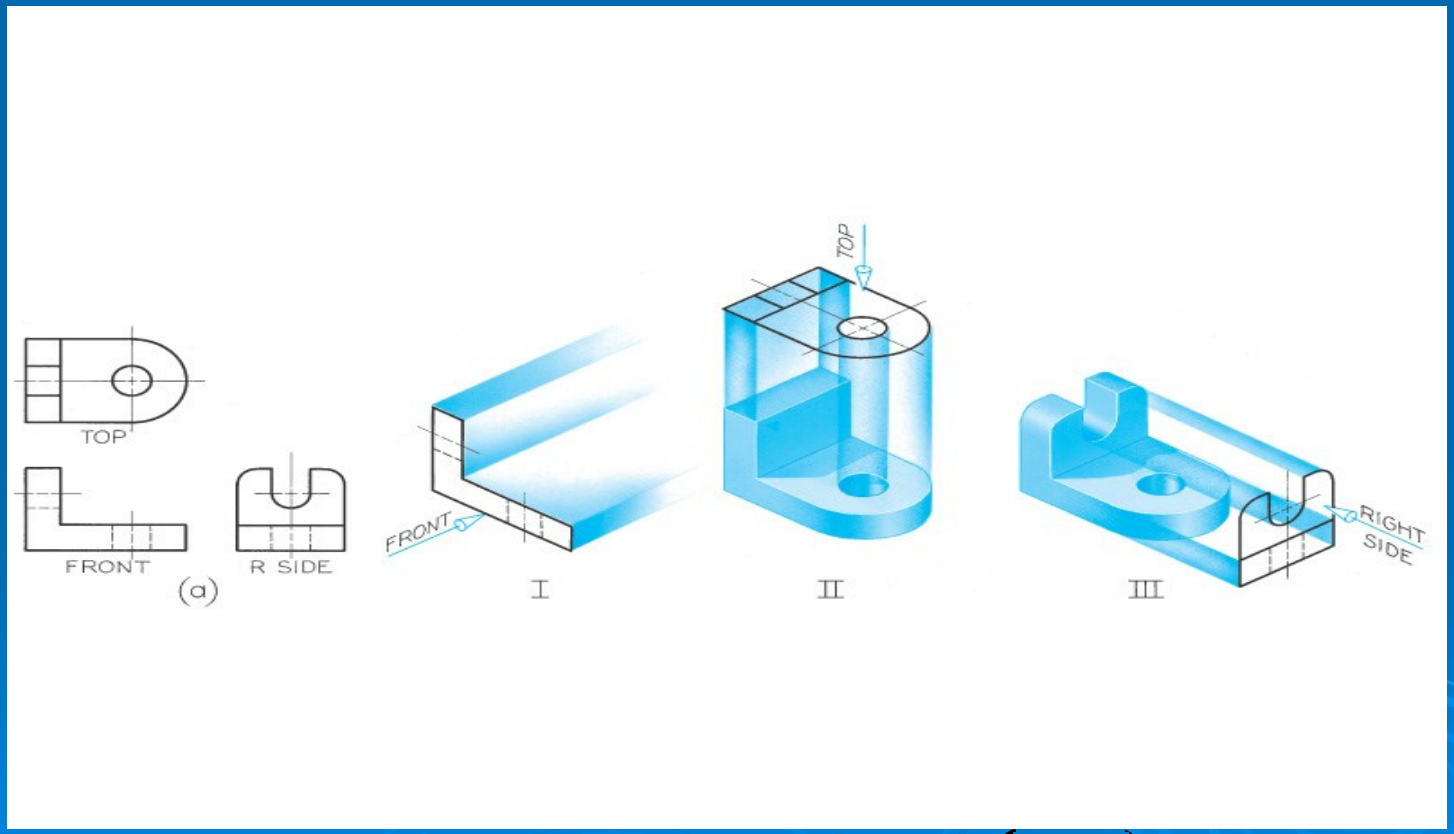


- Surface A is highest, and B is lower than C.

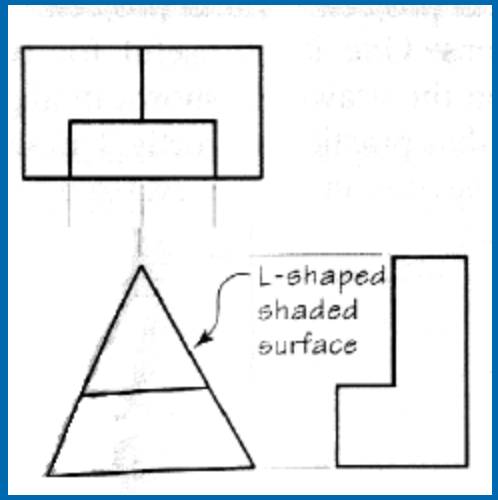


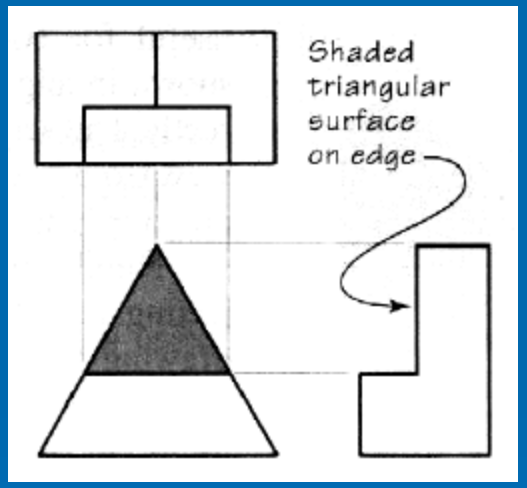
5-26 Interpreting Views

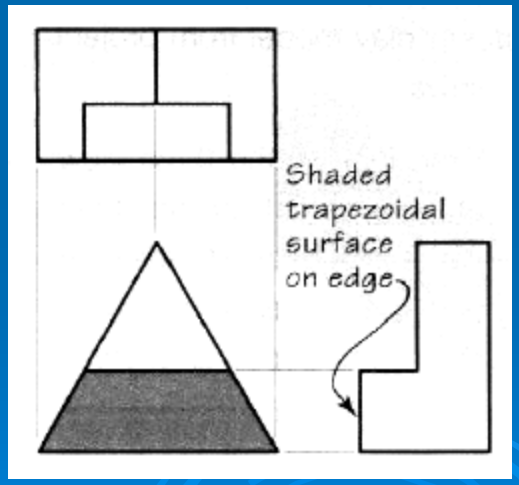
One method of interpreting sketches is to reverse the mental process used in projecting them. This mental process is actually used to construct the solid models for the given drawing.



Step by Step 5.2 (Surfaces)

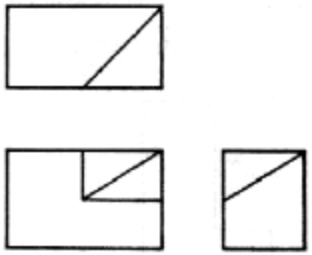






Step by Step 5.3 (Making a Model)

1. First, look at the three views of the object given. Make your block of clay to the same principal dimensions (height, width, and depth) as shown in the views.



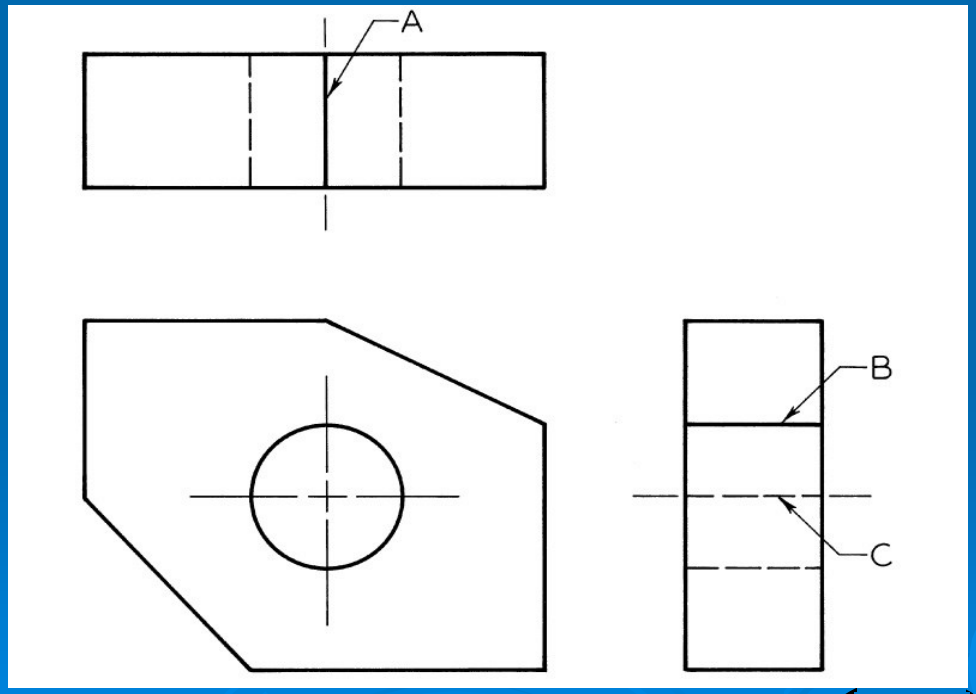
2. Score lines on the frontal surface of your clay block to correspond with those shown on the front view in the drawing. Then do the same for the top and right-side views.

3. Slice straight along each line scored on the clay block to get a 3-D model that represents the projected views.

You will see this approach in solid modeling.

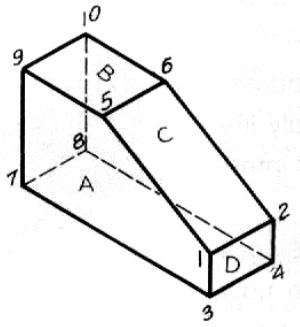
5-29 Precedence of Lines

Visible lines, hidden lines, and centerlines often coincide on a drawing and you have to decide which lines to show. A visible line always takes precedence and covers up a centerline or hidden line when they fall over on top of each other in a view.

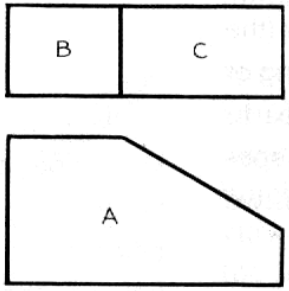


Step by Step 5.4. Projecting a Third View

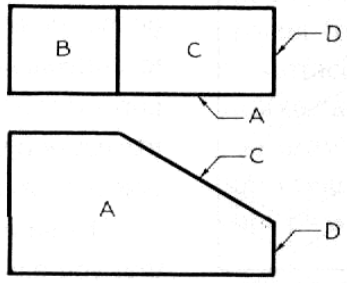
The figure at right is a pictorial drawing of an object to be shown in three views. It has numbers on it identifying each corner (vertex) of the object and letters identifying some of the major surfaces. You are given the top and front view. You will use point numbers to project the side view.



1. To number points effectively you first need to identify surfaces and interpret the views that are given. First label visible surfaces that have an easy to identify shape in one view. Then locate that same surface in the adjacent view. (The surfaces on the pictorial object have been labeled to make it easy.)



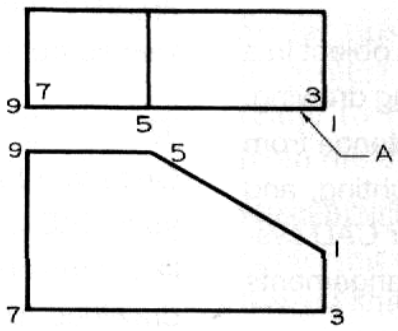
2. Surface A in the front view is a normal surface. It will appear as a horizontal line in the top view. The two rectangular surfaces, B and C in the top view are a normal surface and an inclined surface. They will show as a horizontal line and an inclined line in the front view, respectively.



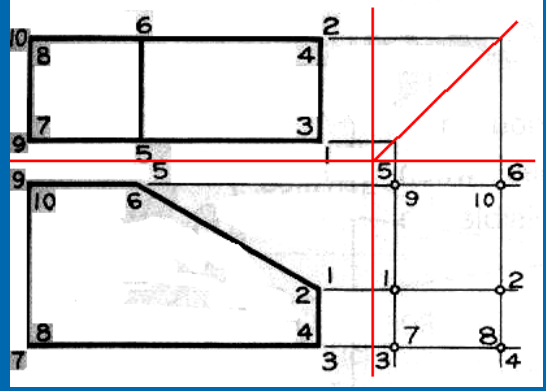
3. Once you have identified the surfaces, label the vertices of a surface that has an easy to recognize shape, in this case surface A.

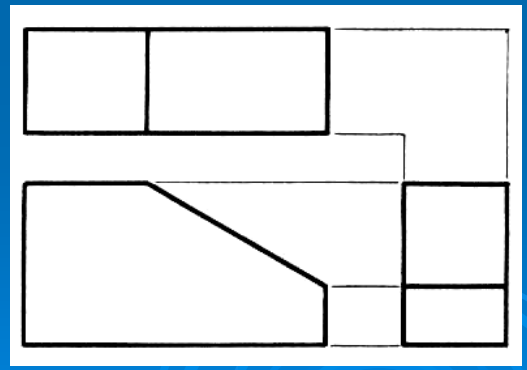
Label its vertices with numbers at each corner as shown. If a point is directly visible in the view, place the number outside the corner

If the point not directly visible in that view, place the numeral inside the corner. Using the same numbers to identify the same points in different views will help you to project known points in two views to unknown positions in a third view.



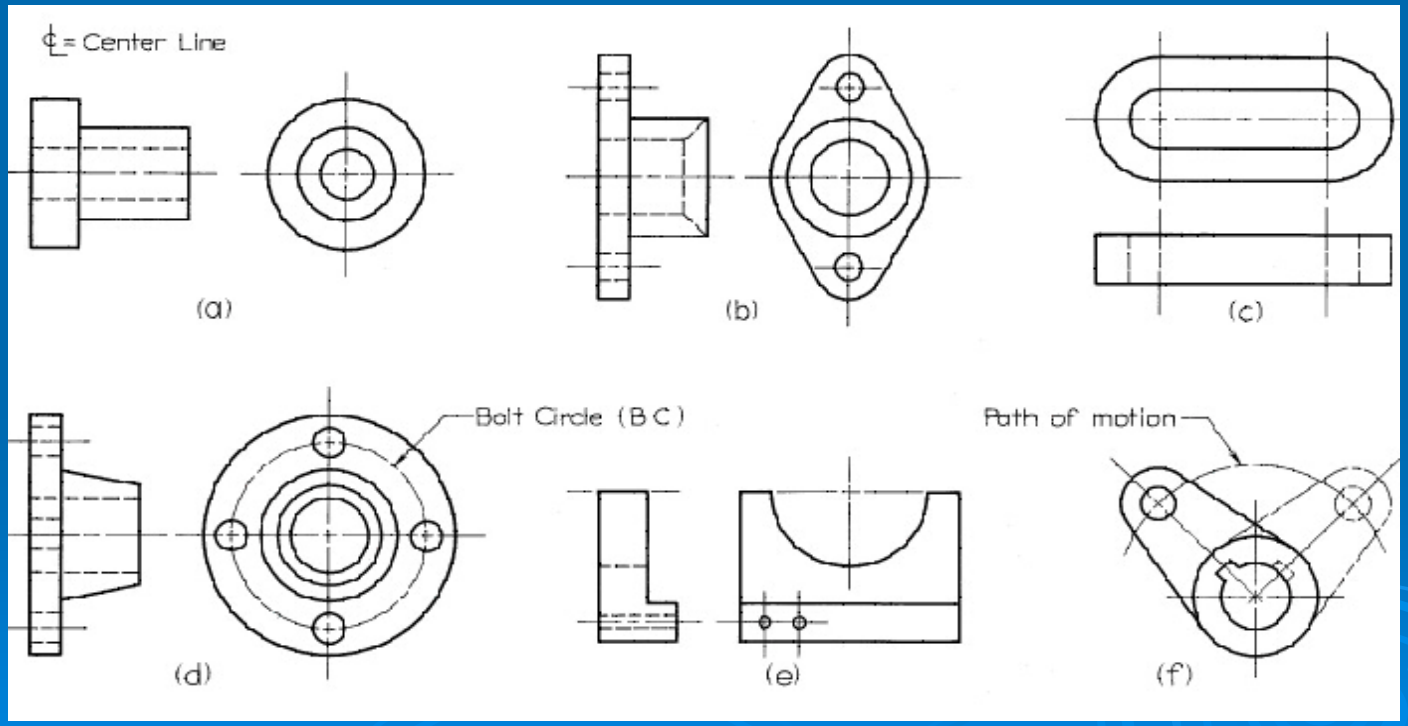
7. Project the remaining points using the same method, proceeding surface by surface.





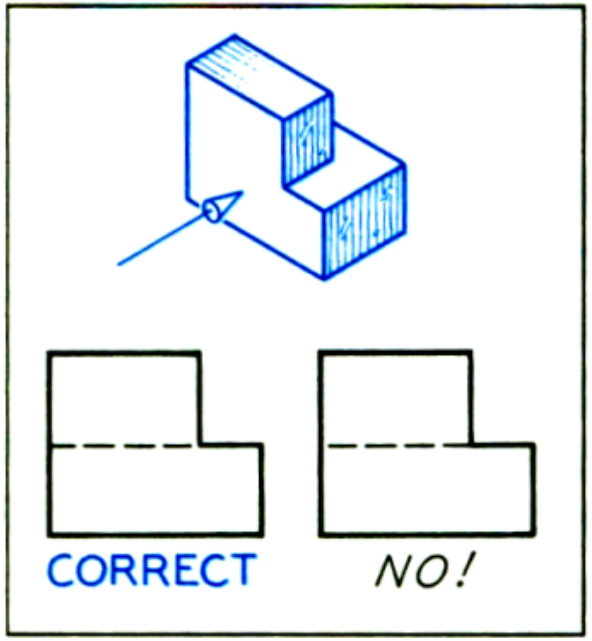
5-30 Lines

Thick, dark lines are used to represent features of the object that are directly visible. Dashed hidden lines are used to represent features that would be hidden behind other surfaces. Centerlines are used to indicate symmetrical axes of object or features, bolt circles, and paths of motion.



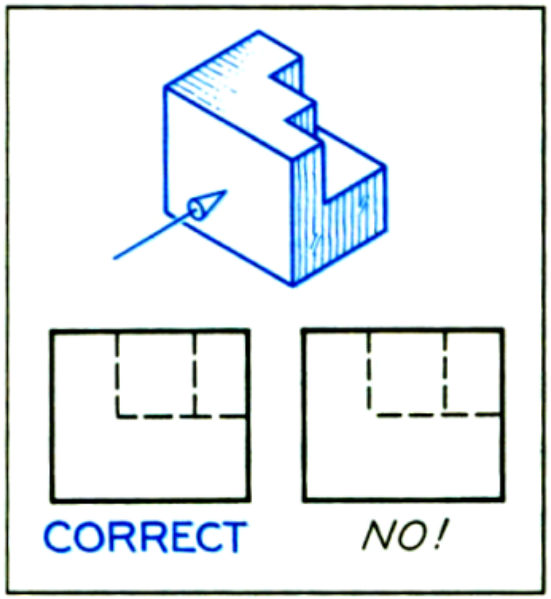
Step by Step 5.5. Correct and Incorrect Practices of Hidden Lines: Case 1

- Make a hidden line join a visible line, except when it causes the visible line to extend too far, as shown here.
- Leave a gap whenever a hidden line is a continuation of a visible line.



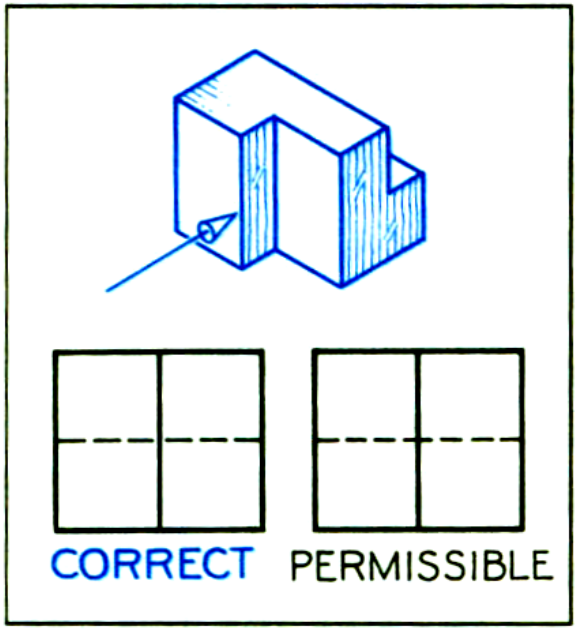
Case 2

- Make hidden lines intersect to form L and T corners.



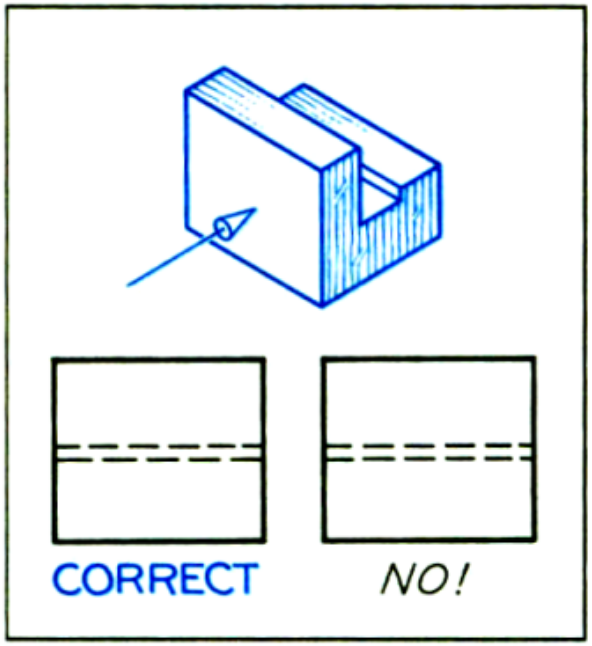
Case 3

- Make a hidden line "jump" a visible line when possible.



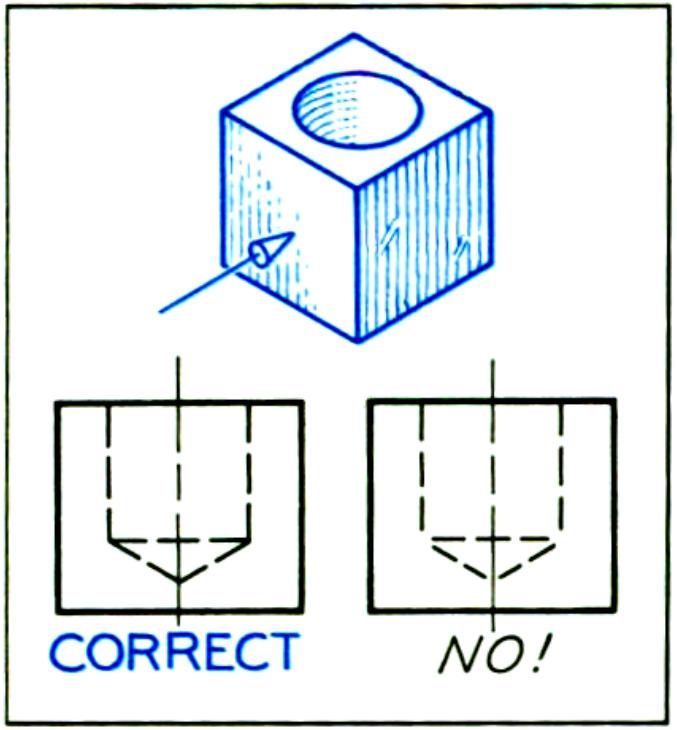
Case 4

- Draw parallel hidden lines so that the dashes are staggered, as in bricklaying.



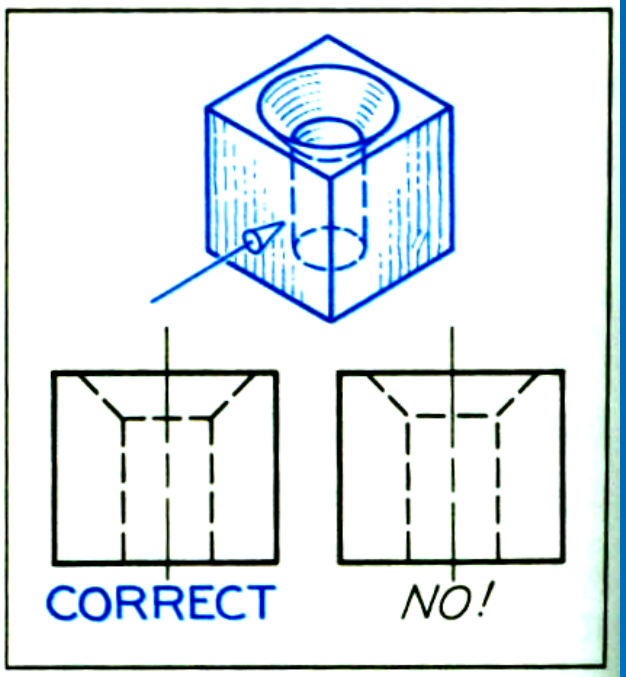
Case 5

- When two or three hidden lines meet at a point, join the dashes, as shown for the bottom of this drilled hole.



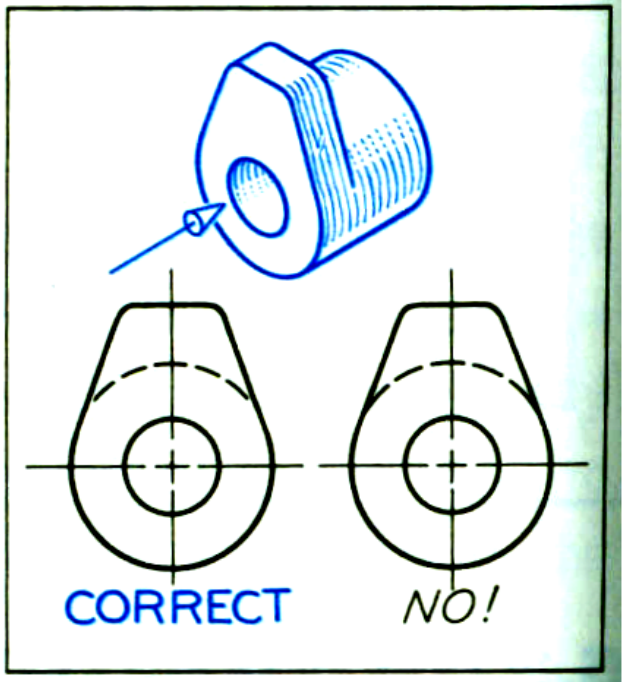
Case 6

- The same rule of joining the dashes when two or three hidden lines meet at a point applies for the top of this counter-sunk hole.



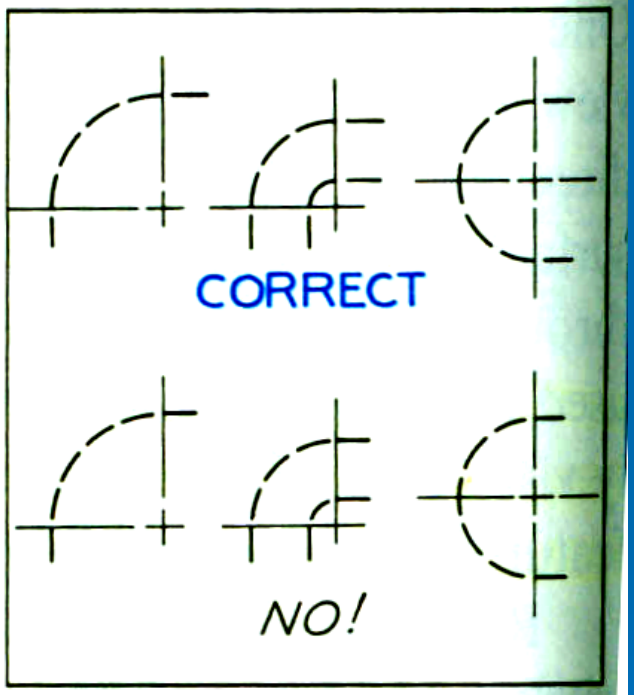
Case 10

- Hidden lines should not join visible lines when this makes the visible line extend too far.



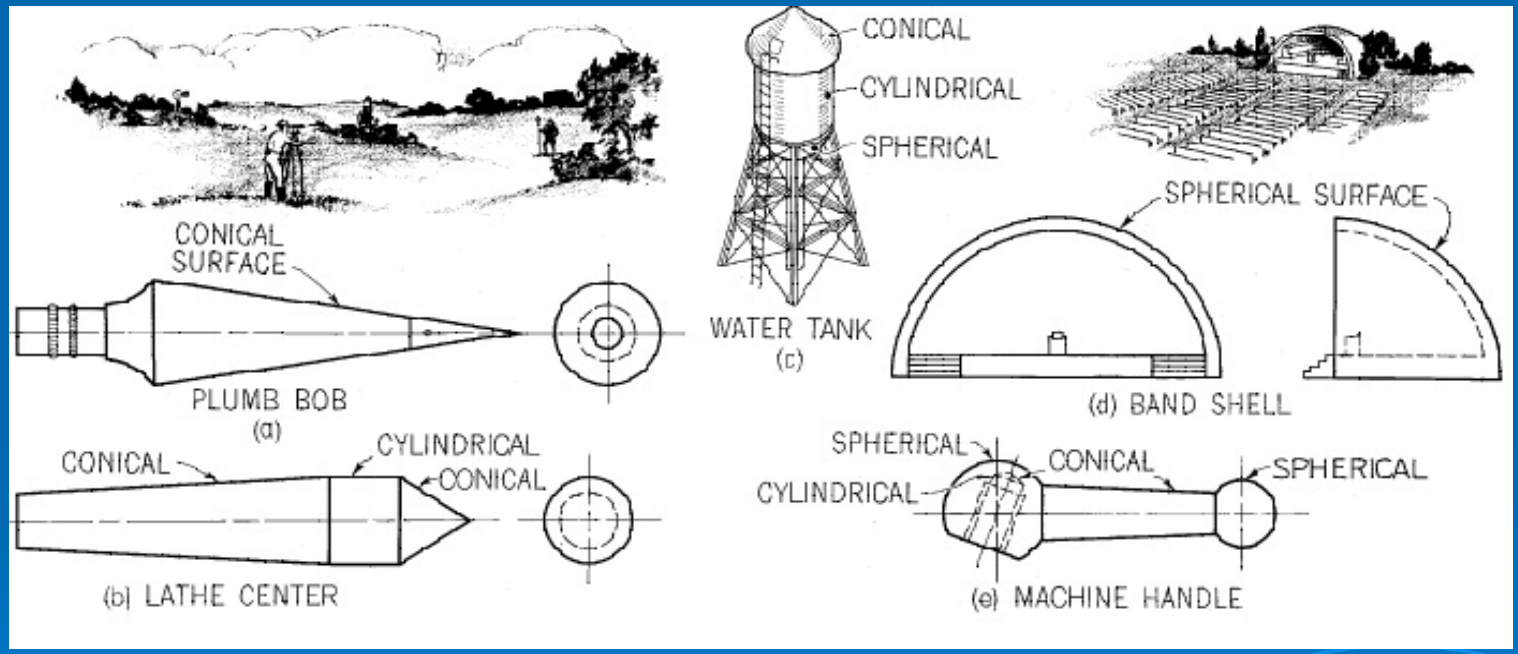
Case 11

- Draw hidden arcs like the upper example. Not like the example below.

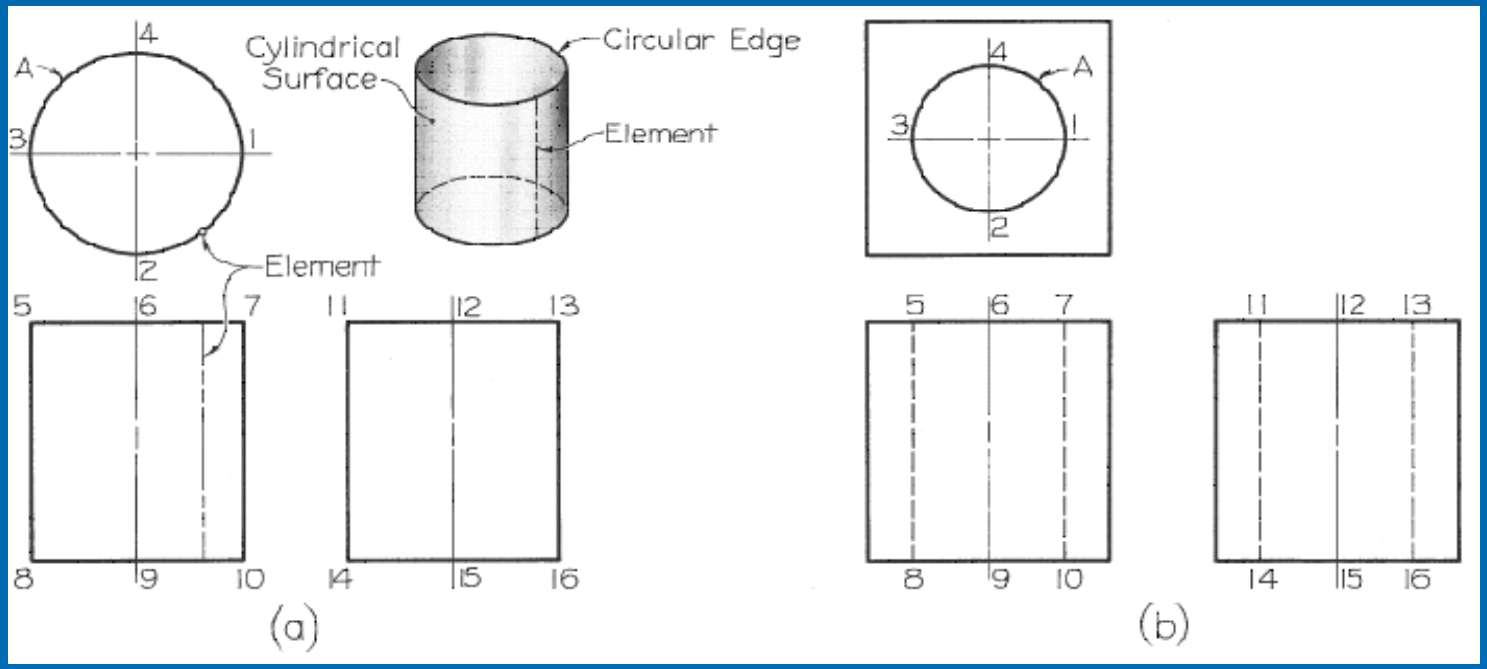


5-32 Curved Surfaces

Some examples of the most common rounded surfaces found in engineering – the cylinder, cone, and sphere – are shown below. Can you find more just around you?

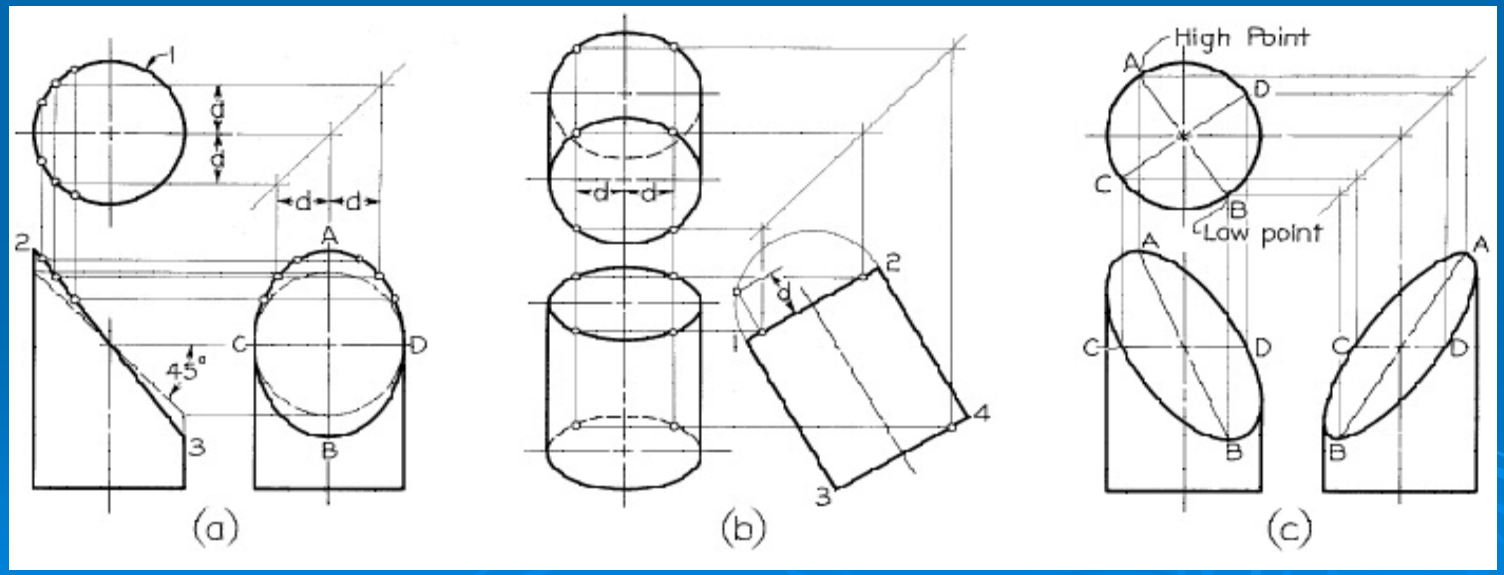


5-33 Cylindrical Surfaces



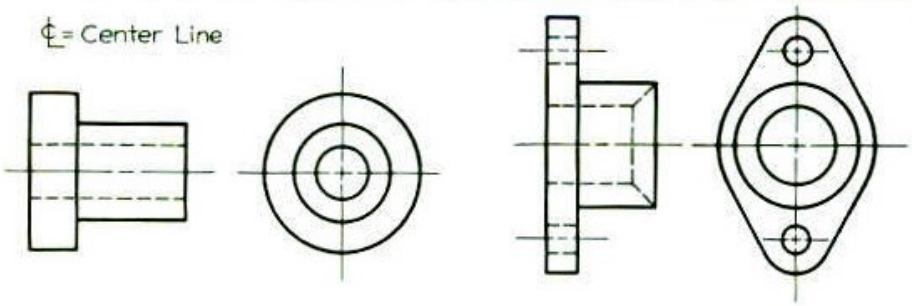
5-34 Cylinders and Ellipses

If a cylinder is cut by an inclined plane, as shown in figure (a), the inclined surface is bounded by an ellipse. This ellipse will appear as a circle in the top view, as a straight line in the front view, and as an ellipse in the side view. If the cut is 45 degrees from the horizontal, it will also appear as a circle in the side view.

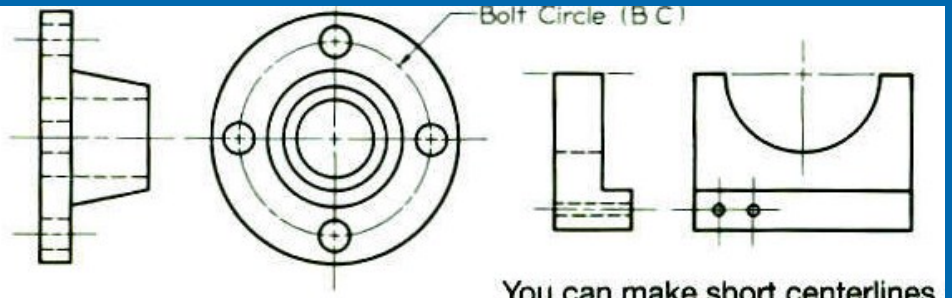


Step by Step 5.6. Sketching Centerlines

- As in the examples shown, sketch a single centerline in the longitudinal view, and crossed centerlines in the circular view.
- Make sure the small dashes cross at the intersections of the centerlines.
- Make centerlines extend uniformly about 8 mm outside the feature for which they are drawn.

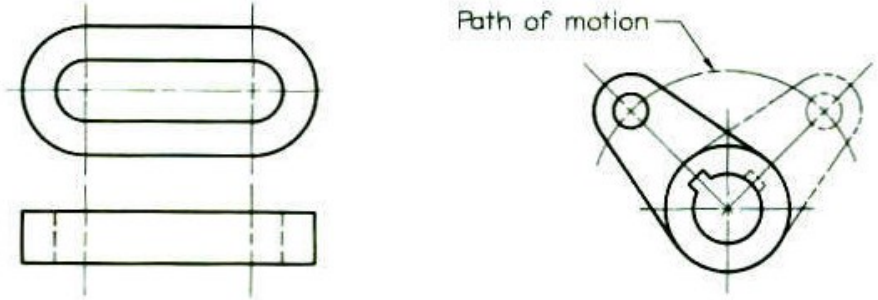


- The long dashes of centerlines may vary from 20 to 40 mm or more in length, depending on the size of the drawing.
- Make the short dashes about 5 mm long, with spaces of about 2 mm.
- Always start and end centerlines with long dashes.



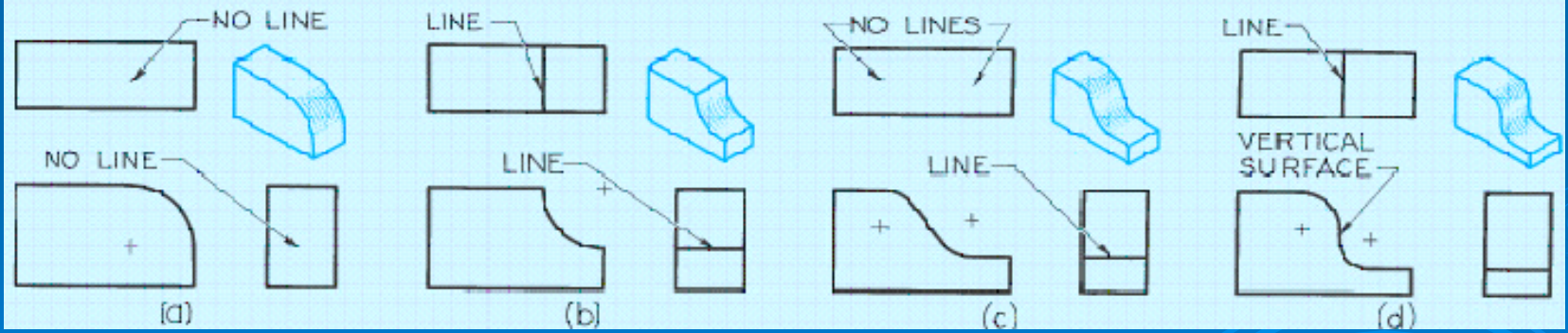
You can make short centerlines solid, especially for small holes.

- Always leave a gap when a centerline forms a continuation of a visible or hidden line.
- Make centerlines thin enough to contrast well with the visible and hidden lines, but dark enough that they can be seen clearly and reproduce well.



5-35 Intersections and Tangencies

No line is drawn where a curved surface is tangent to a plane as in fig. (a). When a curved surface intersects a plane as in fig. (b), a definite edge is formed. If curves join each other and plane surfaces smoothly, no line is drawn to show where they come together as in fig. (c). If a combination of curves creates a vertical surface, Fig. (d), the vertical surfaces is shown as a line.



When plane surfaces join a contoured surface, they do not show a line if they are tangent, but do show a line if they intersect. Examples of planes joining contoured surfaces are shown below.

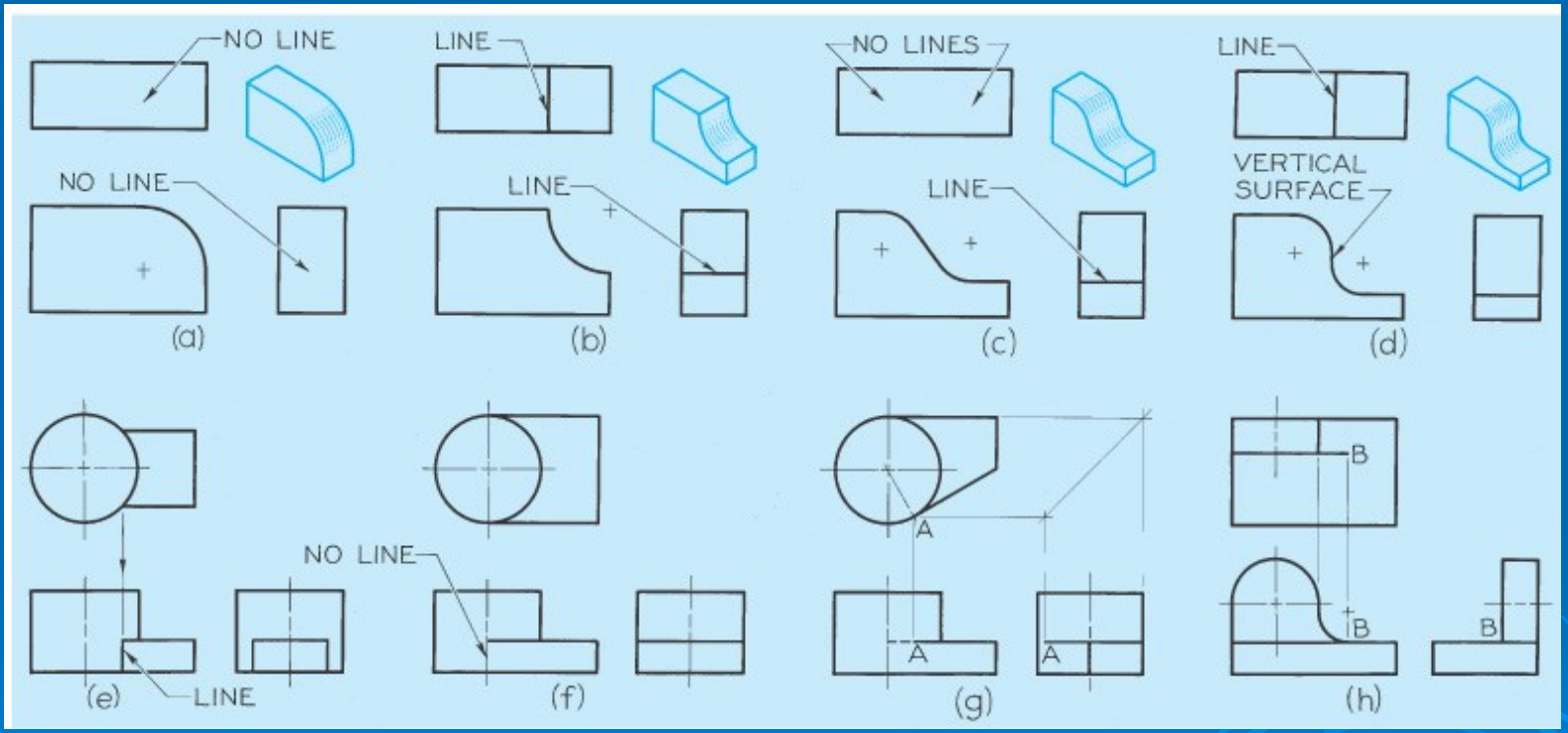
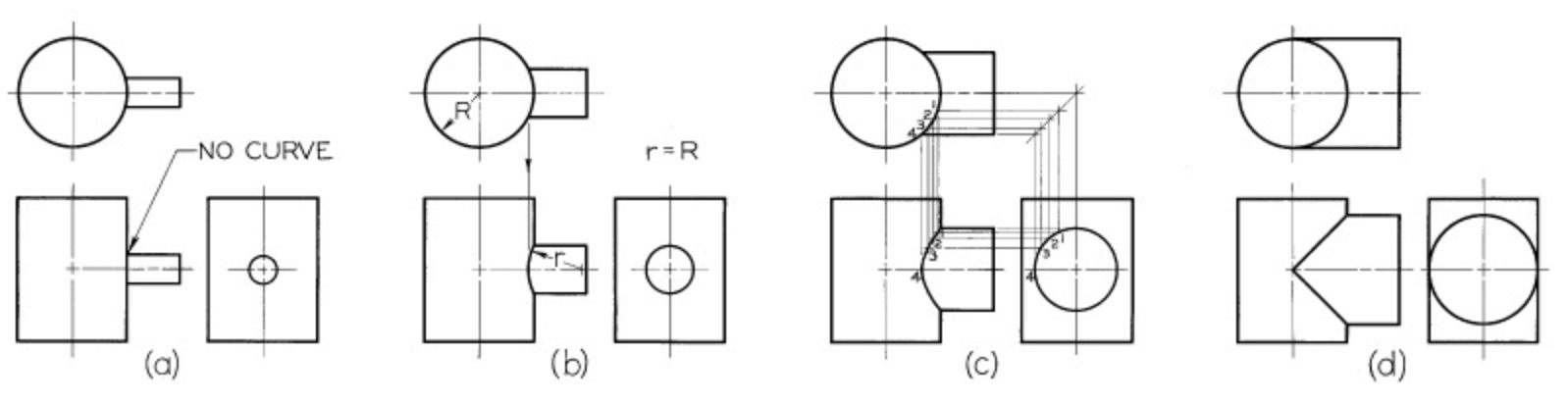
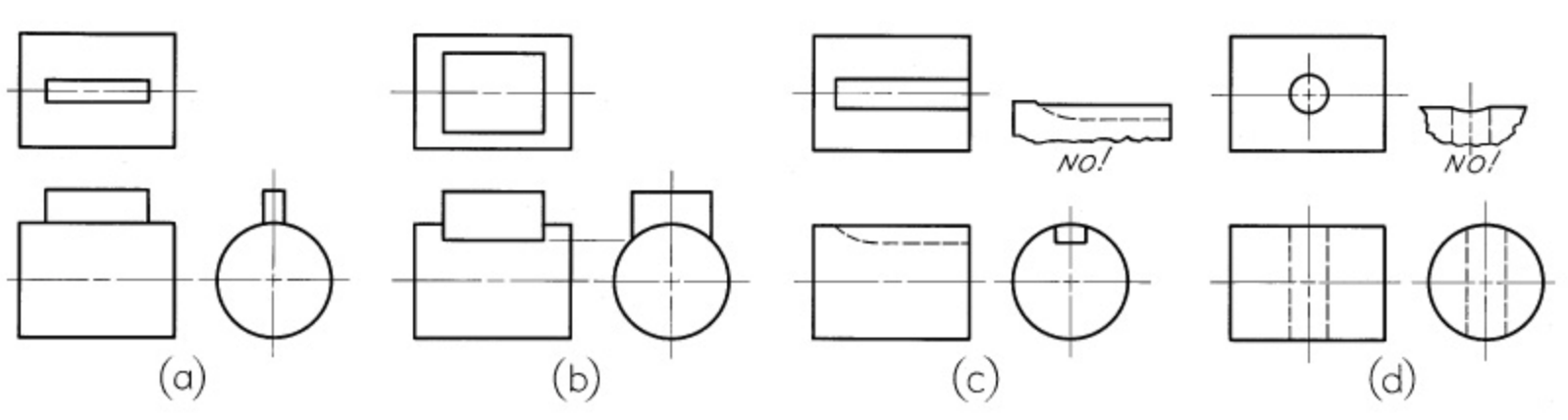


Figure (a) shows an example of a small cylinder intersecting a large cylinder. When the intersection is small, its curved shape is not plotted accurately since it adds little to the sketch or drawing for the time it takes. In stead it is shown as a straight line. When the intersection is larger, it can be approximated by drawing an arc with the radius the same as that of the large cylinder, as shown in Fig. (b).



Large intersections can be plotted accurately by selecting points along the curve to project, as shown in Fig. (c). When the cylinders are the same diameter, their intersection appears as straight lines in the adjoining view, as in Fig. (d).

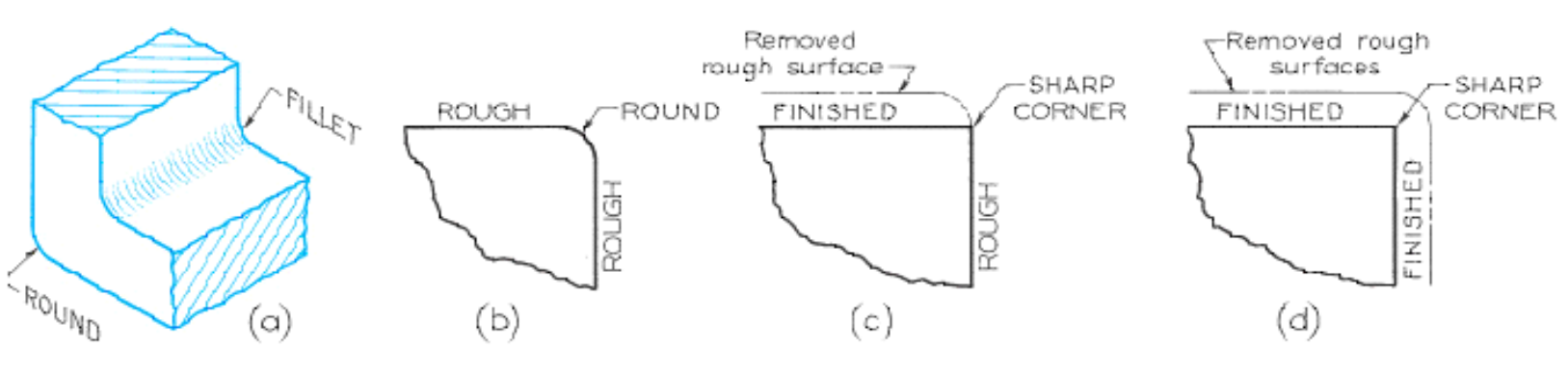
Figures (a) and (b) below show similar examples of a narrow prism intersecting a cylinder.



Figures (c) and (d) show the intersections of a keyseat and cylinder and a small hole and a cylinder.

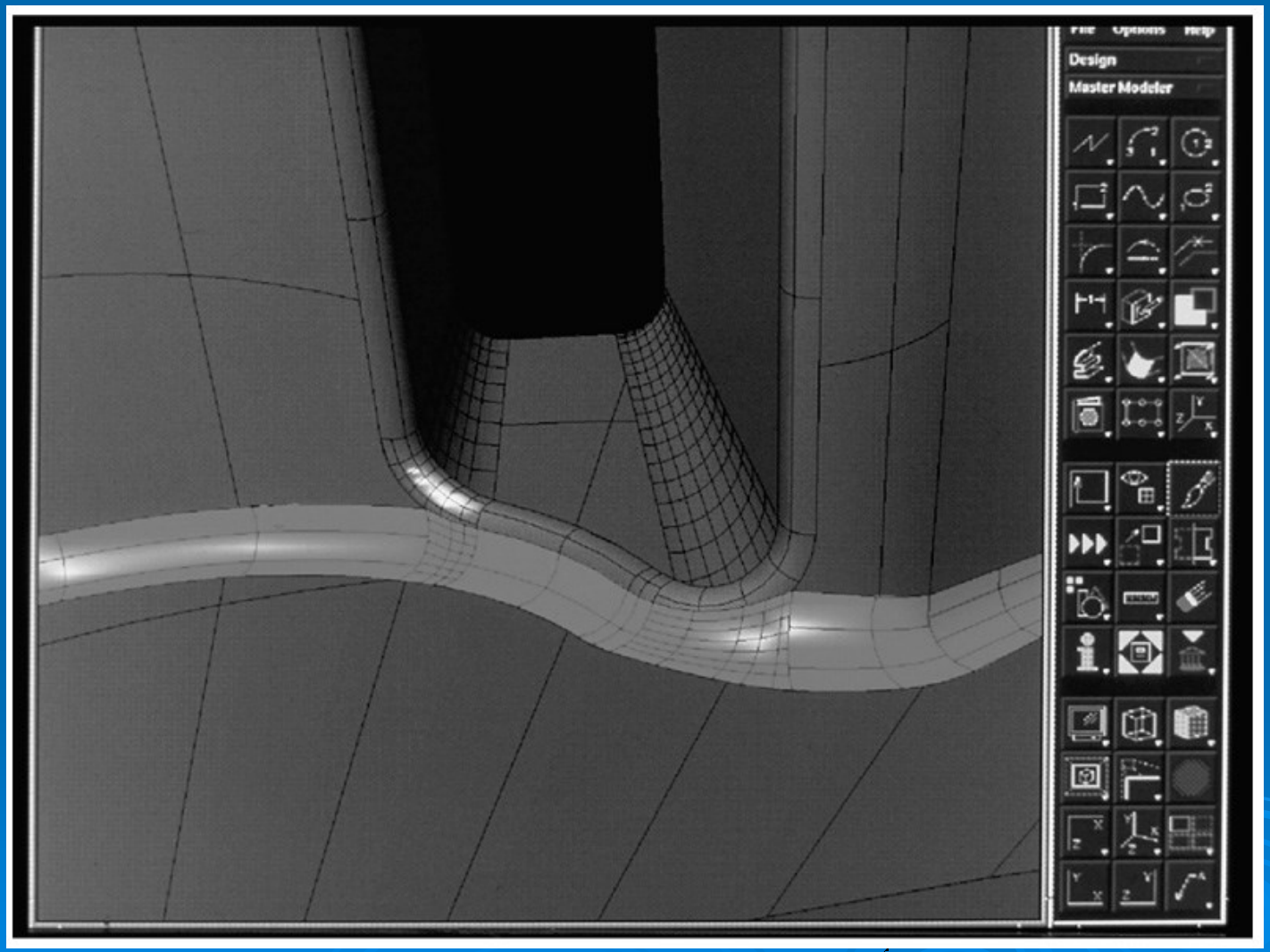
5-36 Fillets and Rounds

A rounded interior corner is called a *fillet* and a rounded exterior corner is called a *round*.

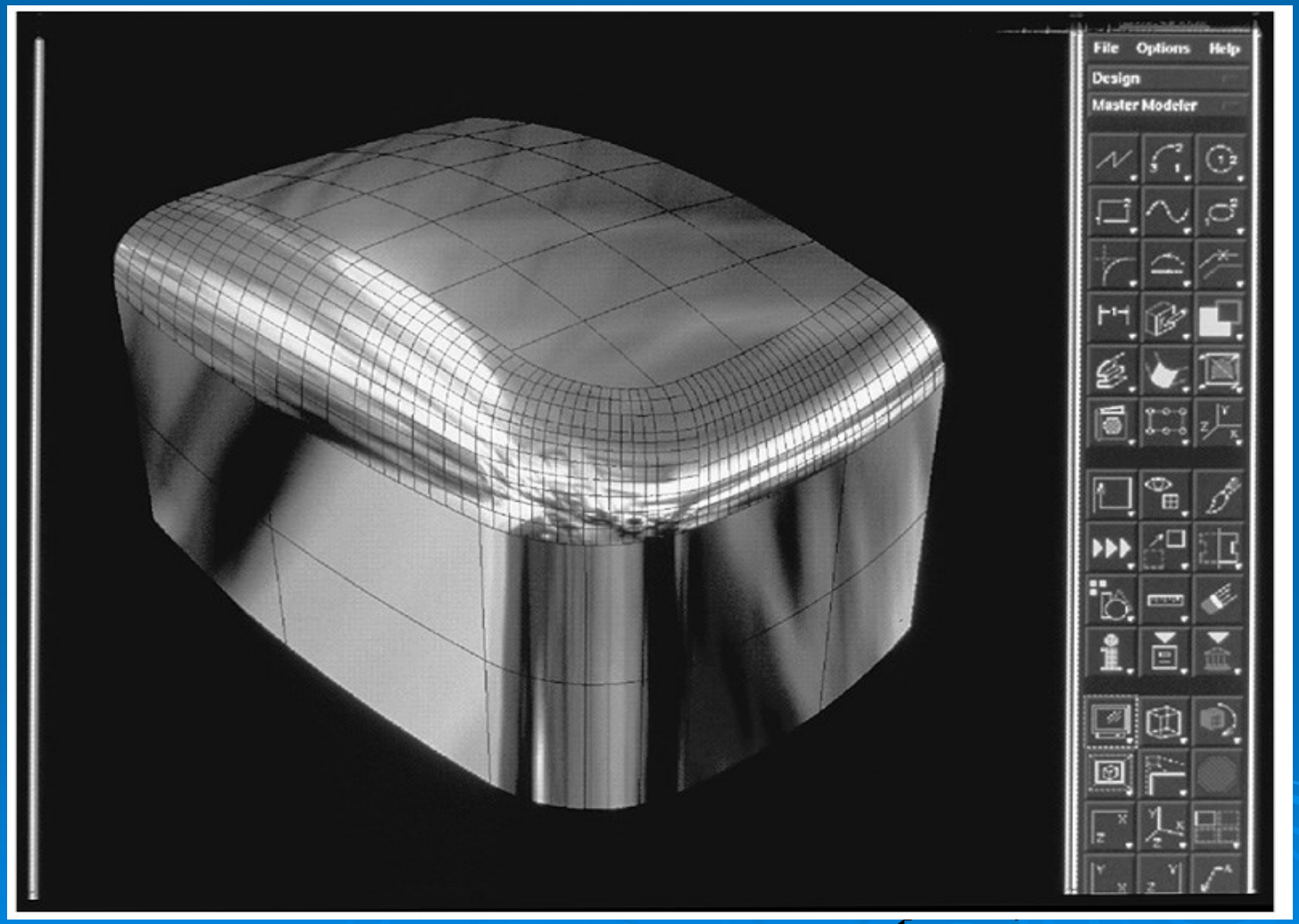


Sharp corners are usually avoided in designing parts to be cast or forged because they are difficult to produce, not safe for human, and can weaken the part (i.e., raises the stresses).

CAD example (Fillet)

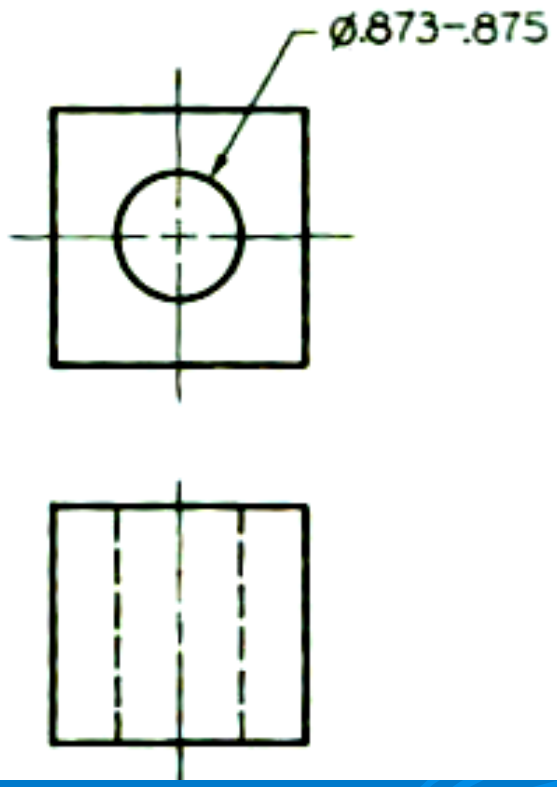


CAD example (Round)



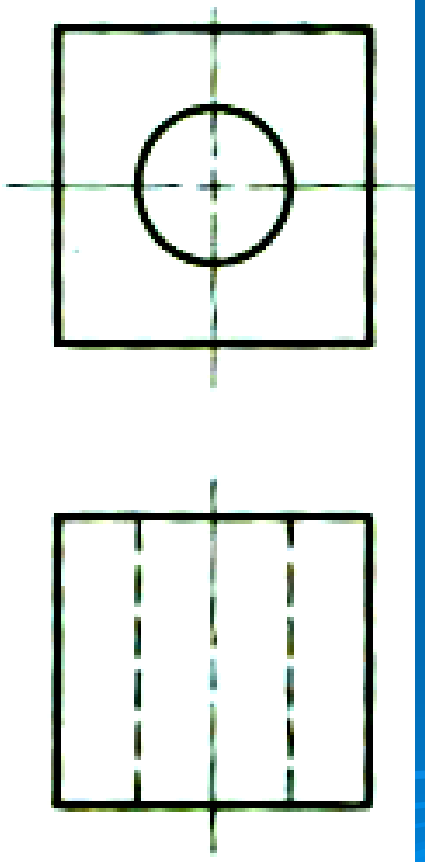
Step by Step 5.8. Representing Holes: Case 1

- Always specify hole sizes by diameter—never by radius.



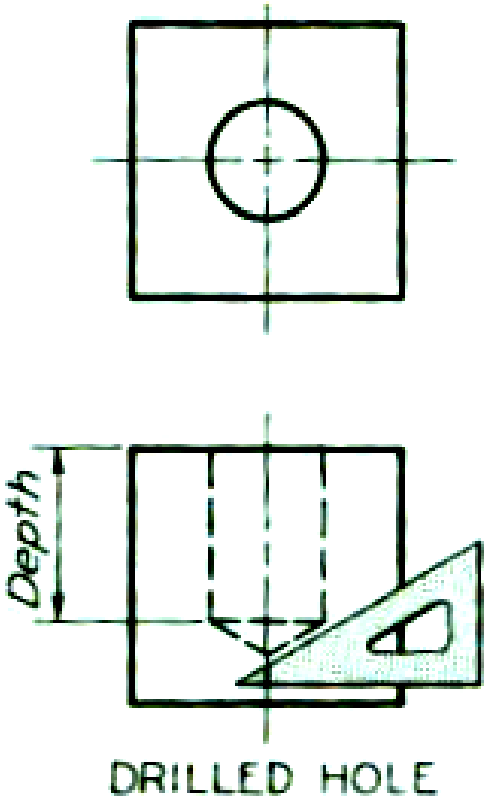
Case 2

- A hole that goes through a member is called a through hole.



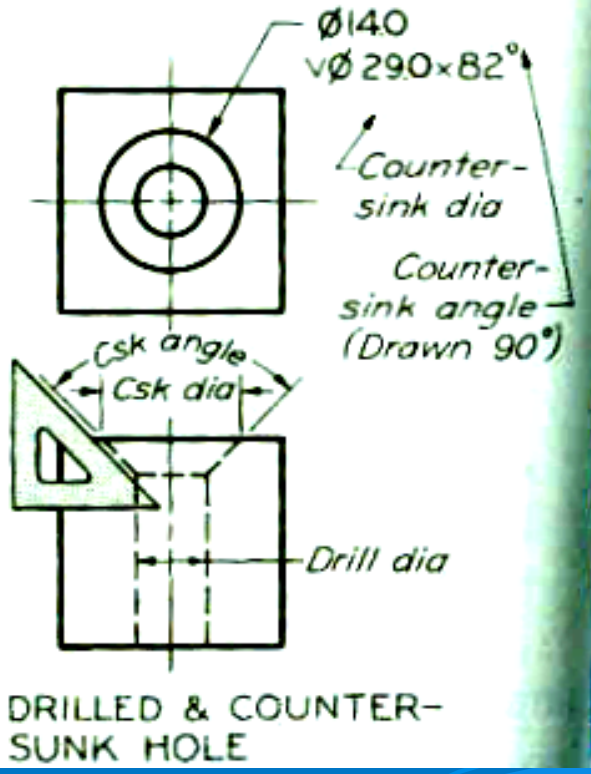
Case 3

- A hole with a specified depth is called a blind hole. In a blind hole, the depth includes the cylindrical portion of the hole only. The point of the drill leaves a conical bottom in the hole, drawn at approximately a 30° angle.



Case 4

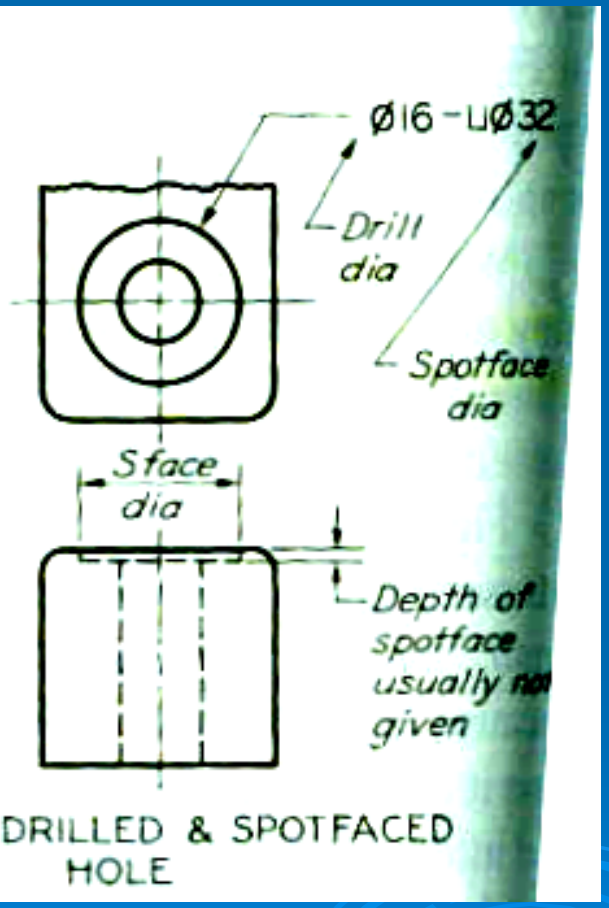
- If a hole is to be drilled with the upper part enlarged conically to a specified angle and diameter—called countersinking—the angle is commonly 82 degrees, but it is drawn at 90 degrees for simplicity.



DRILLED & COUNTER-SUNK HOLE

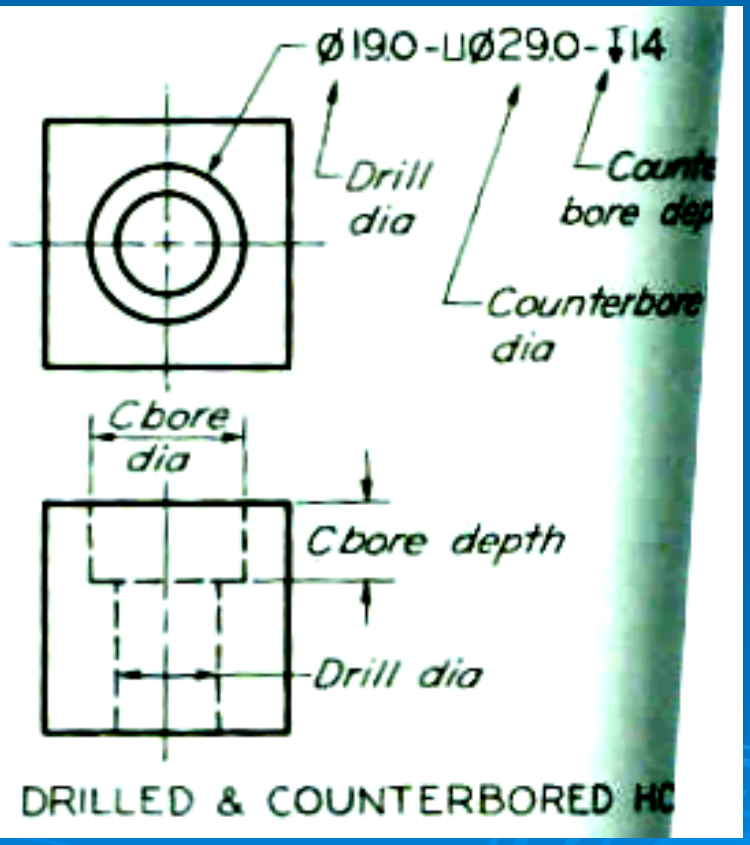
Case 5

- If a hole is to be drilled with the upper part enlarged cylindrically to a specified diameter, usually to produce a smooth bearing surface (called spotfacing), the depth usually is not specified but is left to the shop to determine For average cases, draw the depth as 1.5 mm (1/16").



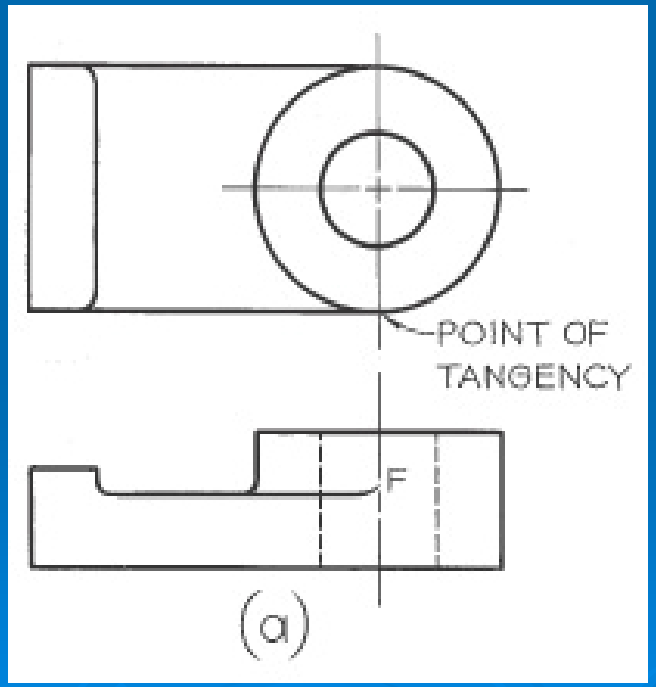
Case 6

- If a hole is to be drilled and the upper part is to be enlarged cylindrically to a specified diameter and depth, called counterboring, it should be specified like this:

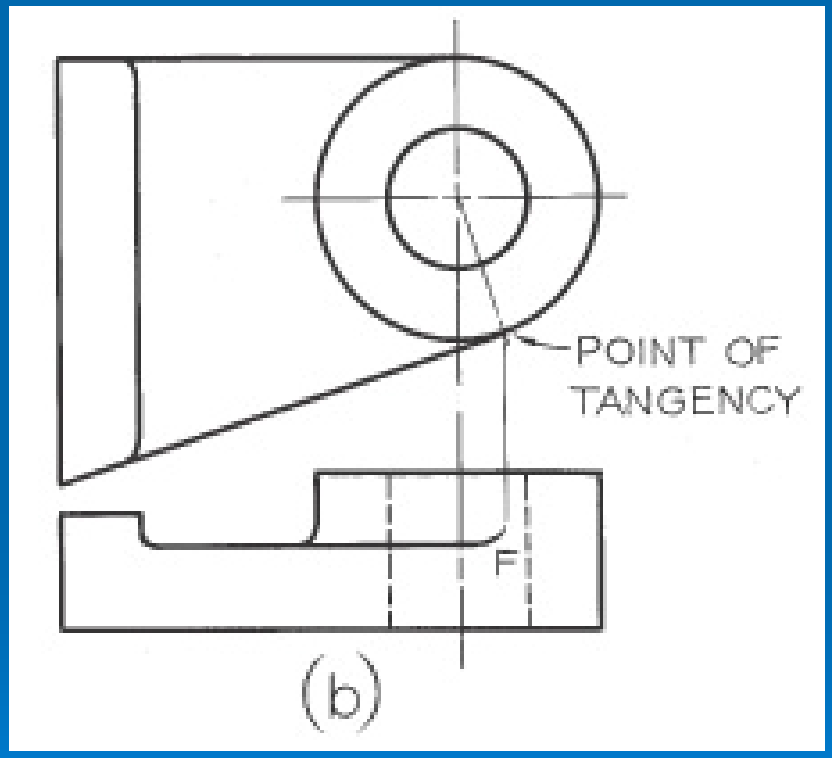


5-37 Runouts: Case 1

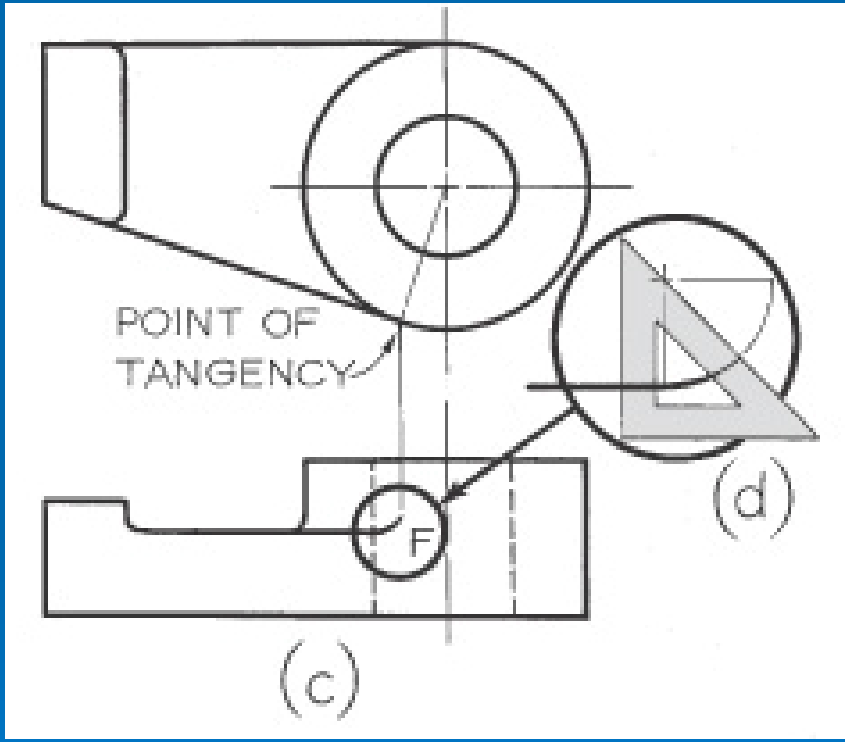
Small curves called runouts (i.e., end of rounds) are used to represent fillets that connect with plane surfaces tangent to cylinders, as shown below. The runouts, labeled F, should have a radius equal to that of the fillet and a curvature of about 1/8 of a circle, as shown in (d).



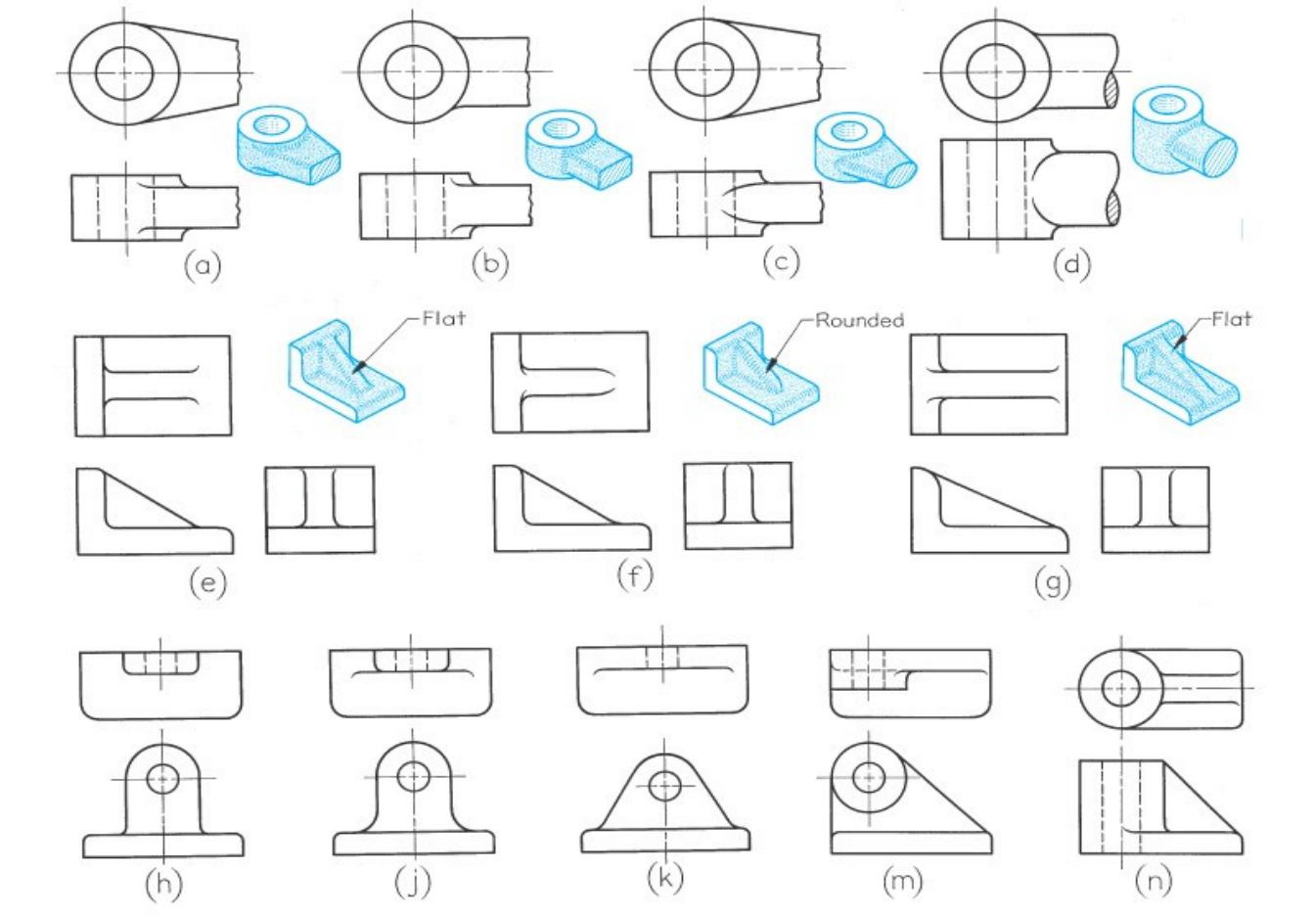
Case 2



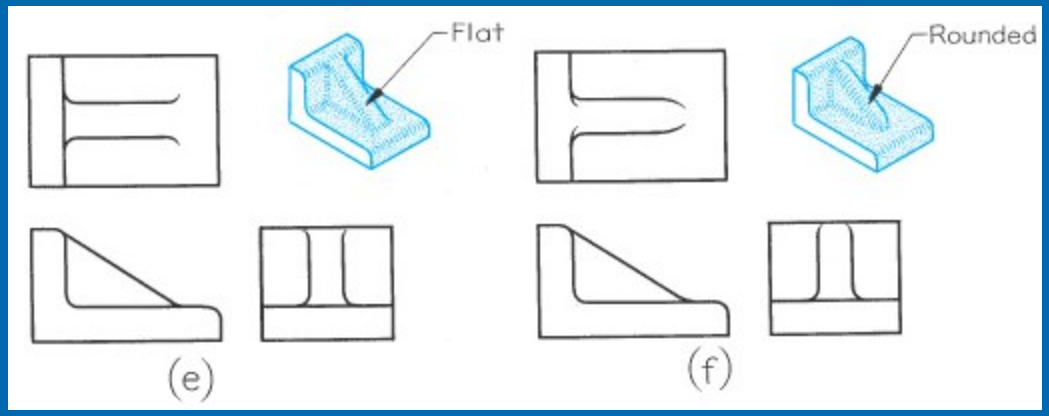
Case 3



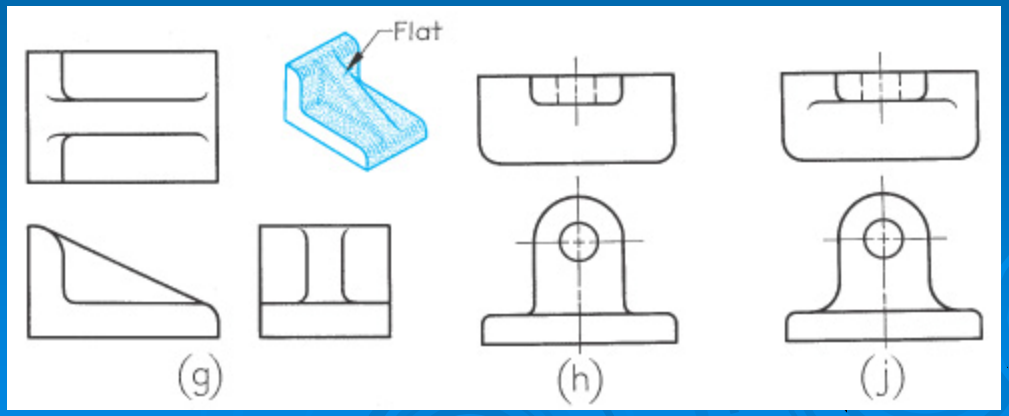
The runouts from different filleted intersections will appear differently due to the shapes of the horizontal intersecting members. See examples below.



In figures (e) and (f) the runouts differ because the top surface of the web is flat in fig. (e), while the top surface of the web in (f) is considerably rounded.



When two different sizes of fillets intersect, the direction of runout is dictated by the larger fillet as in figs. (g) and (j).

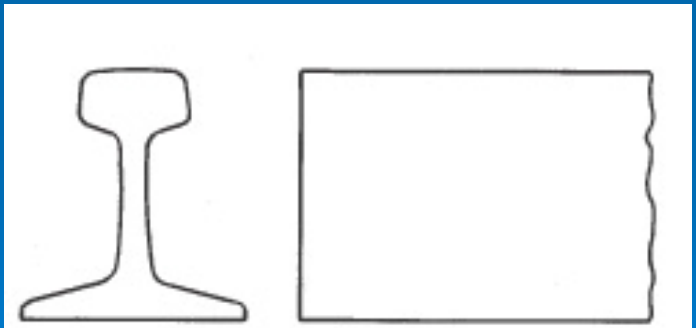


5-38 Conventional Edges

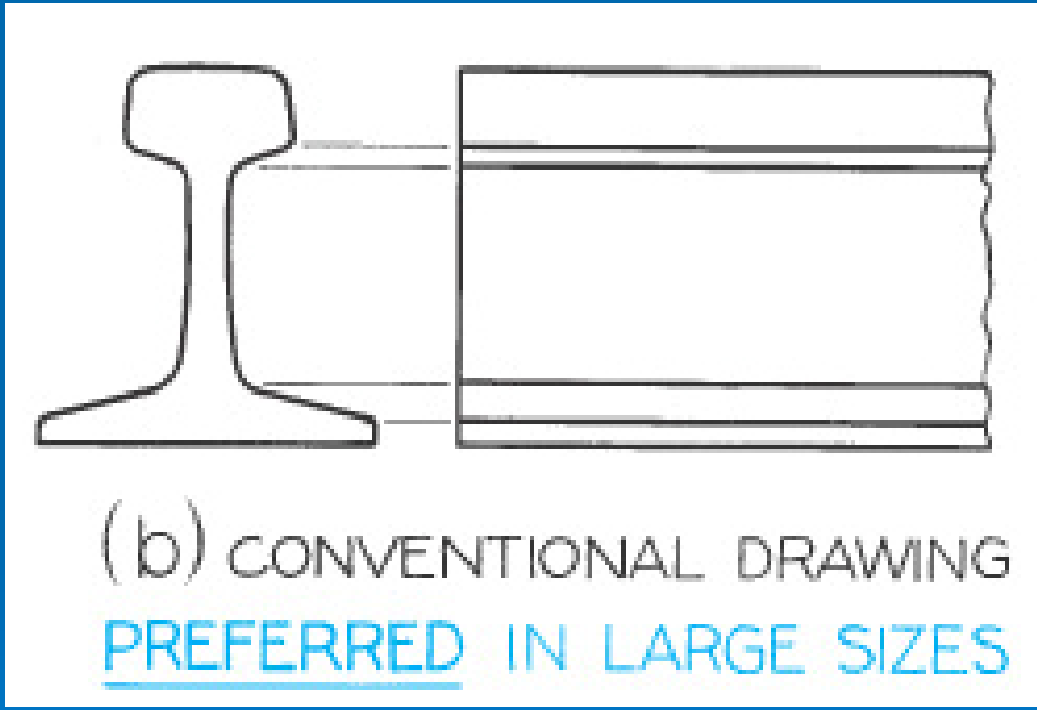
Rounded and filleted intersections eliminate sharp edges and can make it difficult to present the shape clearly. In some cases, as shown in Fig. (a), the true projection may be misleading.

Added lines depicting rounded and filleted edges, as shown in Figs. (b) and (c), give a clear representation, even though it is not a true projection.

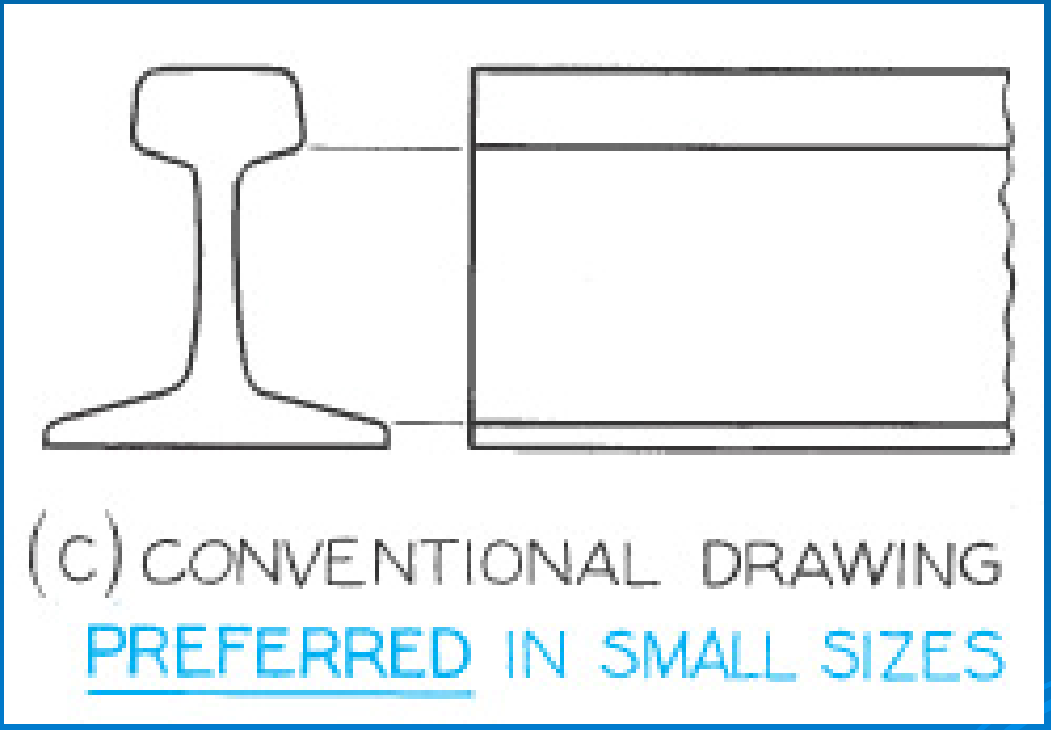
Project the added lines from the intersections of the surfaces as if the rounded and filleted were not present.



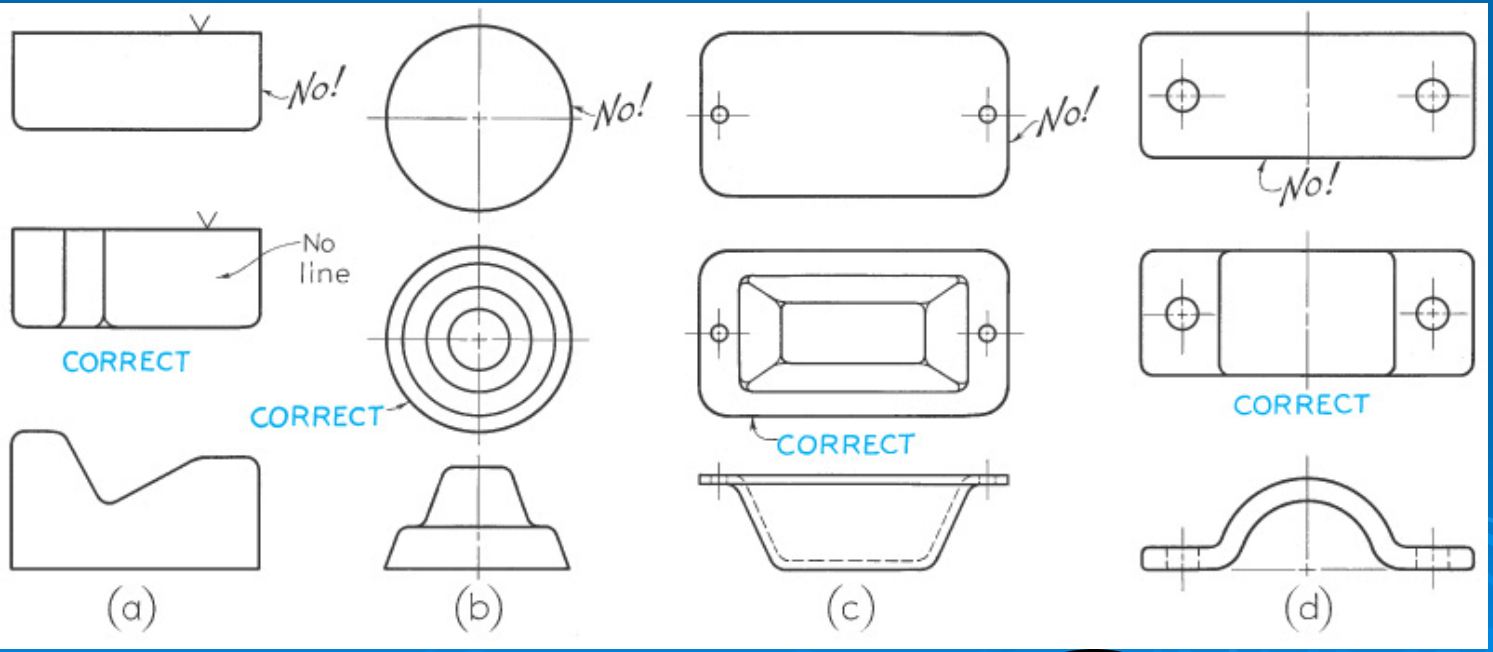
Preferred 1



Preferred 2

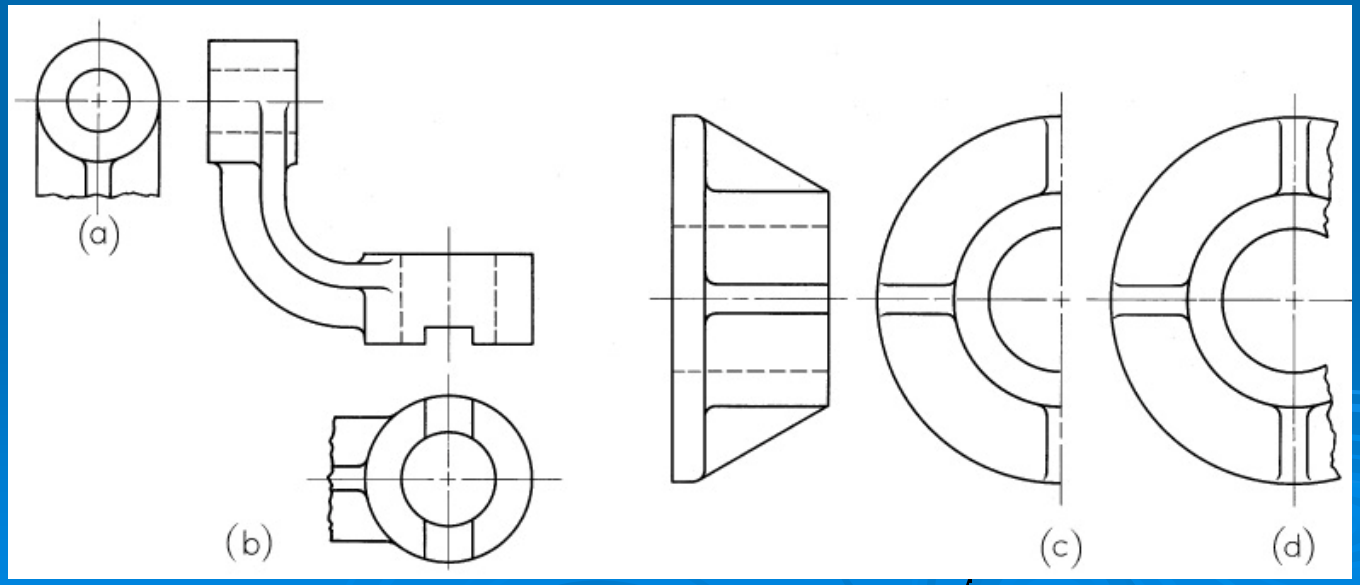


Figures below show the top views for each given front view. The first set of top views have very few lines, even though they are the true projections. The second set of top views, where lines are added to represent the rounded and filleted edges, are quite clear. Note the use of the small Y's where rounded and filleted edges meet a rough surface. If an edge intersects a finished surface, no Y is shown.



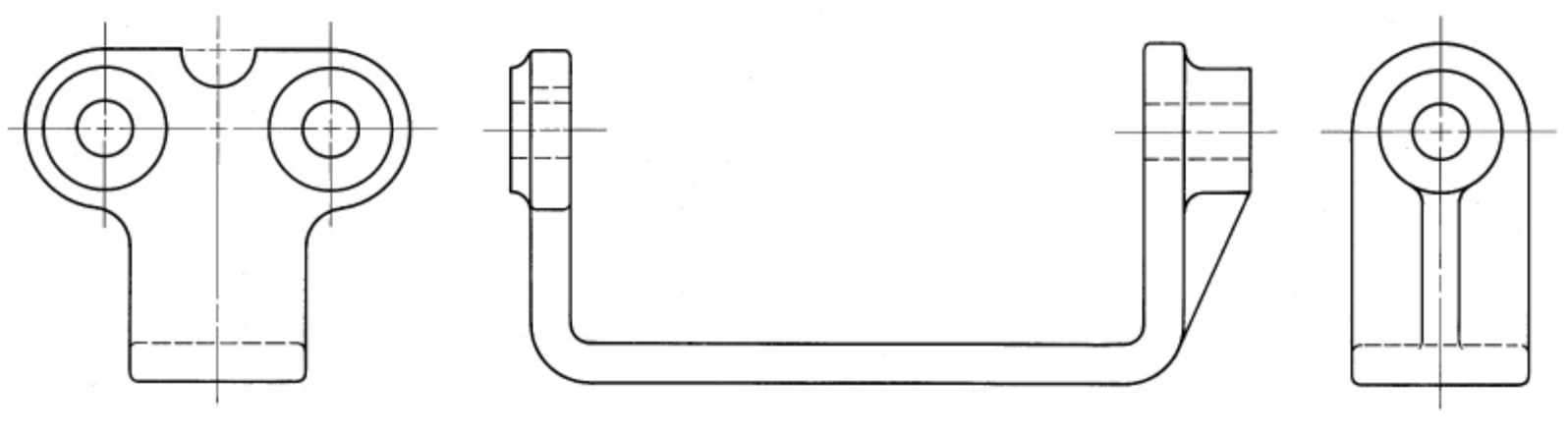
5-40 Partial Views

A view may not need to be complete, but only need to show what is necessary to clearly describe the object. This is called a partial view and is used to save sketching time. You can use a break line to limit the partial view, as shown in figure (a), or limit a view by the contour of the part shown, as shown in fig. (b). If the view is symmetrical, you can draw a half-view on the one side of the centerline, as shown in Fig. (c), or break out a partial view, as shown in fig. (d). The half-views should be the near side, as shown.



When drawing a partial view, do not place a break line where it will coincide with a visible or hidden line, as this may cause the drawing to be misinterpreted.

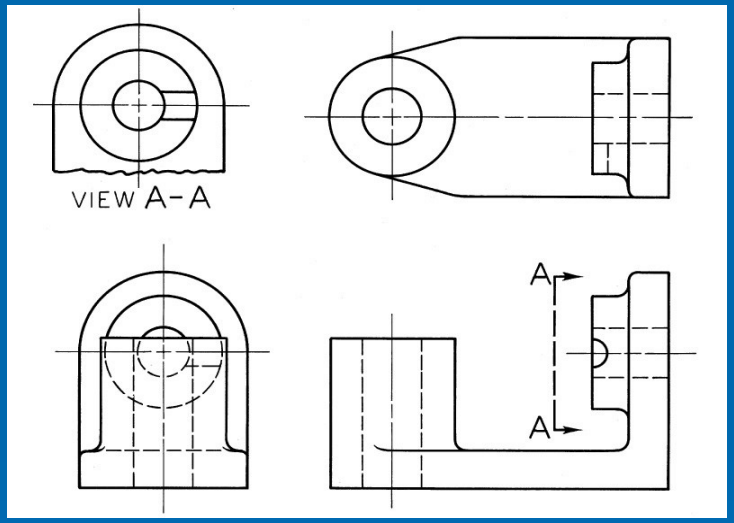
Occasionally the distinctive features of an object are on opposite site. In either complete side view there will be a considerable overlapping of shapes. In cases like this, two side views are often the best solution, as shown in figure below.



The views are partial views, and certain visible and hidden lines have been omitted for clarity.

5-41 Removed Views

A removed view is a complete or partial view removed to another place on the sheet so that it no longer is in direct projection with any other view, as shown below.



A removed view may be used to show a feature of the object more clearly, possibly to a larger scale, or to save drawing a complete regular view.

A viewing-plane line is used to indicate the part being viewed. The arrows at the corners show the direction of sight.

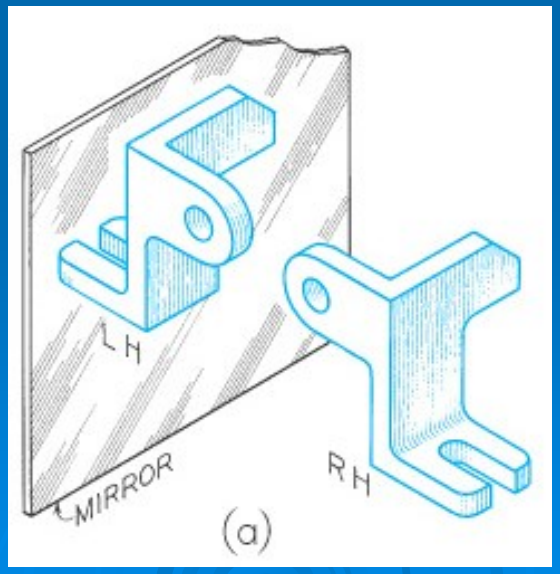
The removed views should be labeled view A-A or view B-B and so on; the letters refer to those placed at the corners of the viewing-plane line.

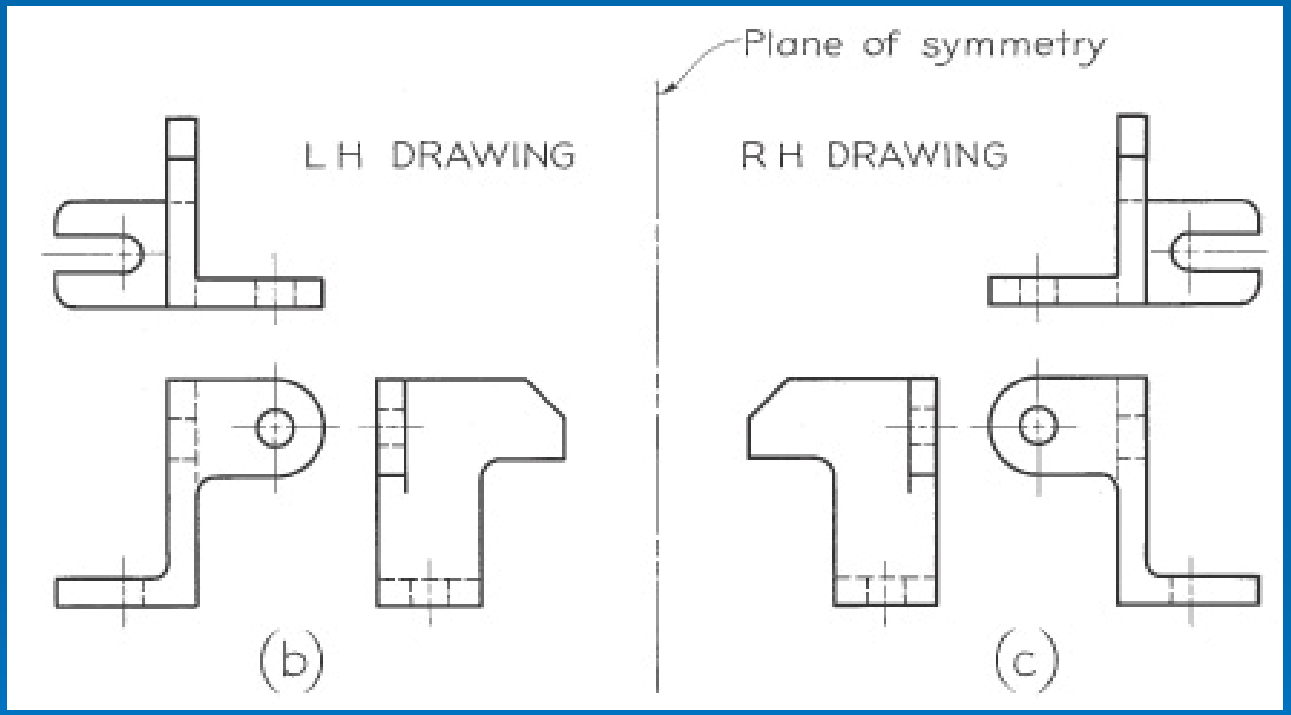
5-44 Right-Hand and Left-Hand Parts

Often individual parts function in pairs where opposite parts are similar. But opposite parts can rarely be exactly alike. On sketches and drawings a left-hand is noted as LH, and right-hand part as RH.

In figure (a), the part in front of the mirror is a right-hand part, and the imagine shows the left-hand part. No matter how the object is turned, the image will show the LH part.

Figures (b) and (c) show the LH and RH drawing of the same object.



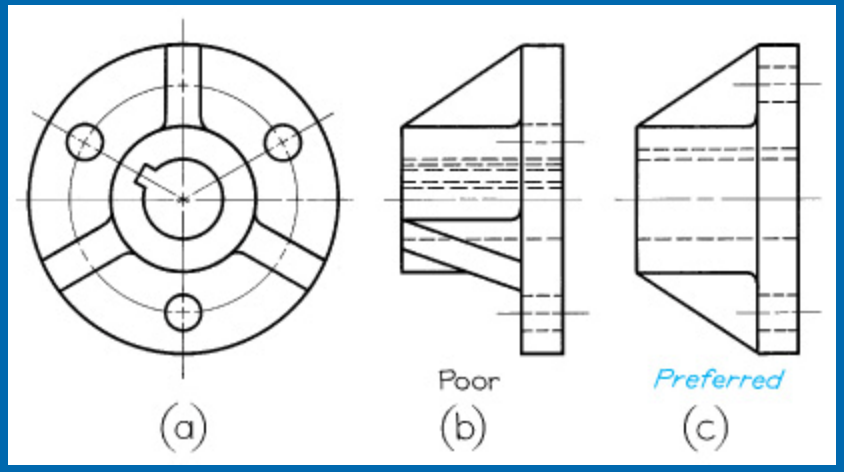

Plane of symmetry
L H DRAWING
R H DRAWING
(b)
(c)

Ordinarily you draw only one of the two opposite parts and label the one that is drawn with a note, such as LH PART SHOWN, RH OPPOSITE.

If the opposite-hand is not clear, you should make a separate sketch or drawing to show it clearly and completely.

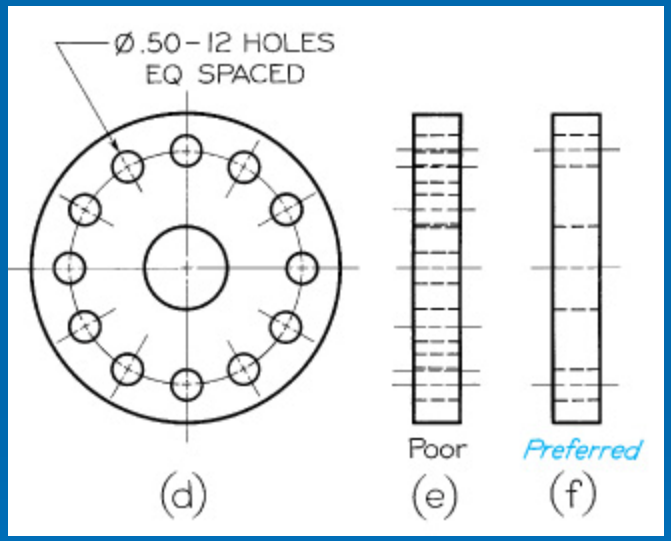
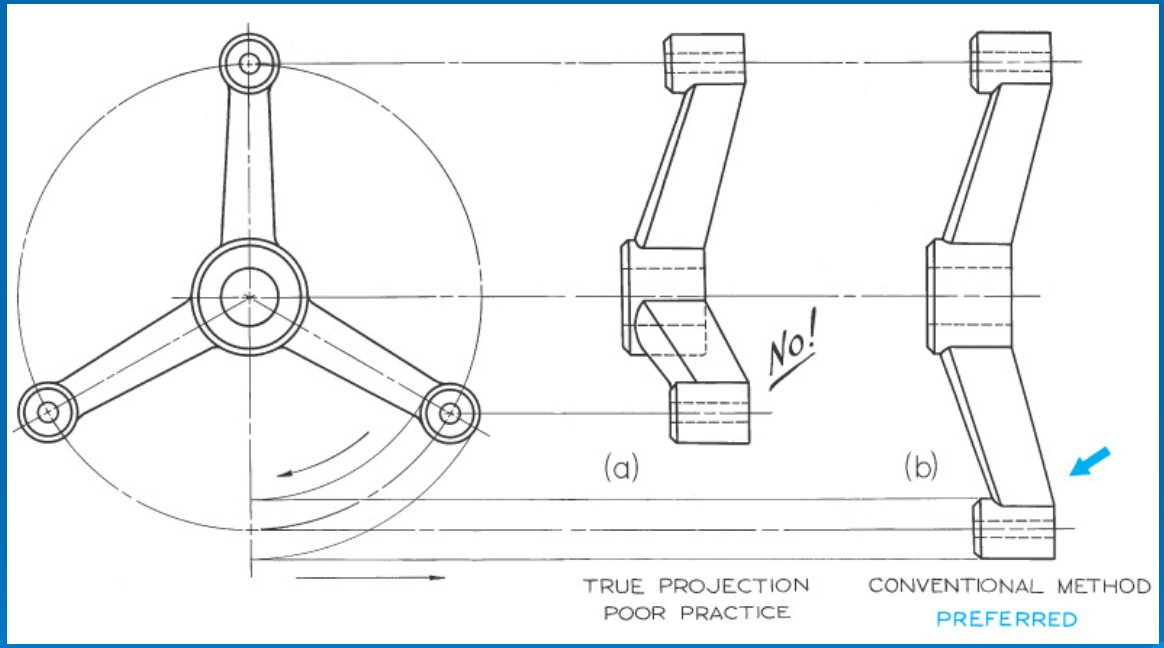
5-45 Revolution Conventions

Regular multiview projections are sometimes awkward, confusing, or actually misleading. For instance, figure (a) shows an object that has three triangular ribs, three holes equally spaced in the base, and a key way.



The right side view is a regular projection and is not recommended – the lower ribs appear in a foreshortened position, the holes do not appear in their true relation to the rim of the base, and the key way is projected as a confusion hidden lines. The conventional method in fig. (c) is preferred because it is simpler to read and requires less time to sketch. Each of the features mentioned has been revolved in the front view to lie along the vertical centerline, from where it is projected to the correct side view.

Figures (d) and (e) show regular views of a flange with many small holes. The hidden holes are confusing and take unnecessary time to show. The preferred representation in fig. (f) shows the holes revolved for clarity.



Figures below show a regular projection with a confusing foreshortening of the inclined arm. To make the object's symmetry clear, the lower arm is revolved to line up vertically in the front view, shown in fig. (b).