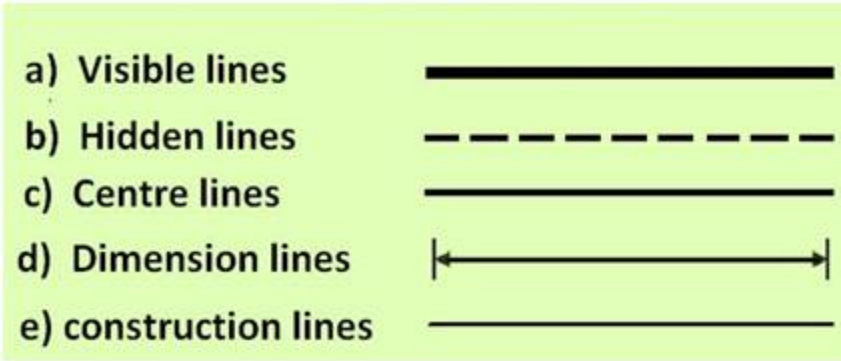
UNIT- 4

Isometric and Orthographic projection

4.1Orthographic projection

Lines are used to construct a drawing. Various type of lines are used to construct meaningful drawings. Each line in a drawing is used to convey some specific information. The types of lines generally used in engineering drawing are shown in Table-1.

Table -1. Types of lines generally used in drawings



- All visible edges are to be represented by visible lines.
- This includes the boundary of the object and intersection between two planes.
- All hidden edges and features should be represented by dashed lines. Figure 1 shows the orthographic front view (line of sight in the direction of arrow)of an object.
- The external boundary of the object is a rectangle and is shown by visible lines.
- In Figure-1(a), the step part of the object is hidden and hence shown as dashed lines while for the position of the object shown in figure-1(b) , the step part is directly visible and hence shown by the two solid lines.

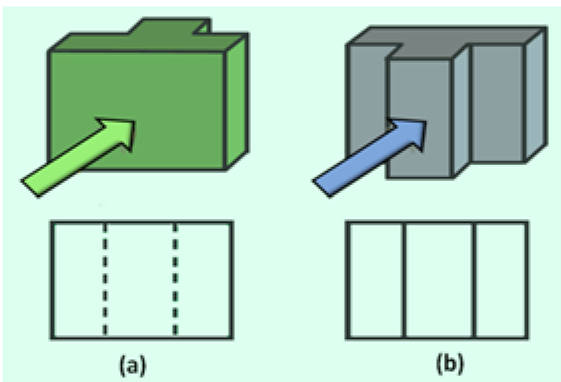


Figure 1 shows the pictorial view and front view of the object when the middle stepped region is (a) hidden and (b) visible.

- **Figure 2** shows the front view (view along the direction indicated by the arrow) of a solid and hollow cylindrical object.
- The front view of the solid cylinder is seen as a rectangle (figure 2(a)).
- For the hollow cylinder in addition to the rectangle representing the boundary of the object, two dashed lines are shown to present the boundary of the hole, which is a hidden feature in the object.
- **Figure 3** shows the Front view of three objects.
- Figure 3(a) is the view of one part of a hollow cylinder which has been split in to two equal parts.
- The wall thickness can be represented by the two visible lines. Figure 3(b) is one part of solid cylinder which has been sectioned in to two equal part.
- Where as figure 3(c) is one part of a solid cylindrical part which has been split in to two unequal parts.
- The edge formed by the intersection of two surfaces is represented by solid lines.
- In case of cylindrical objects or when holes are present in a component, the centre of the holes or centre lines of cylinder will have to be represented in the drawing by means of centre lines as shown in figure 4.
- Figure 5 shows the FV, TV, and RHSV of an object showing visible edges, hidden edges (or holes), and centre lines.

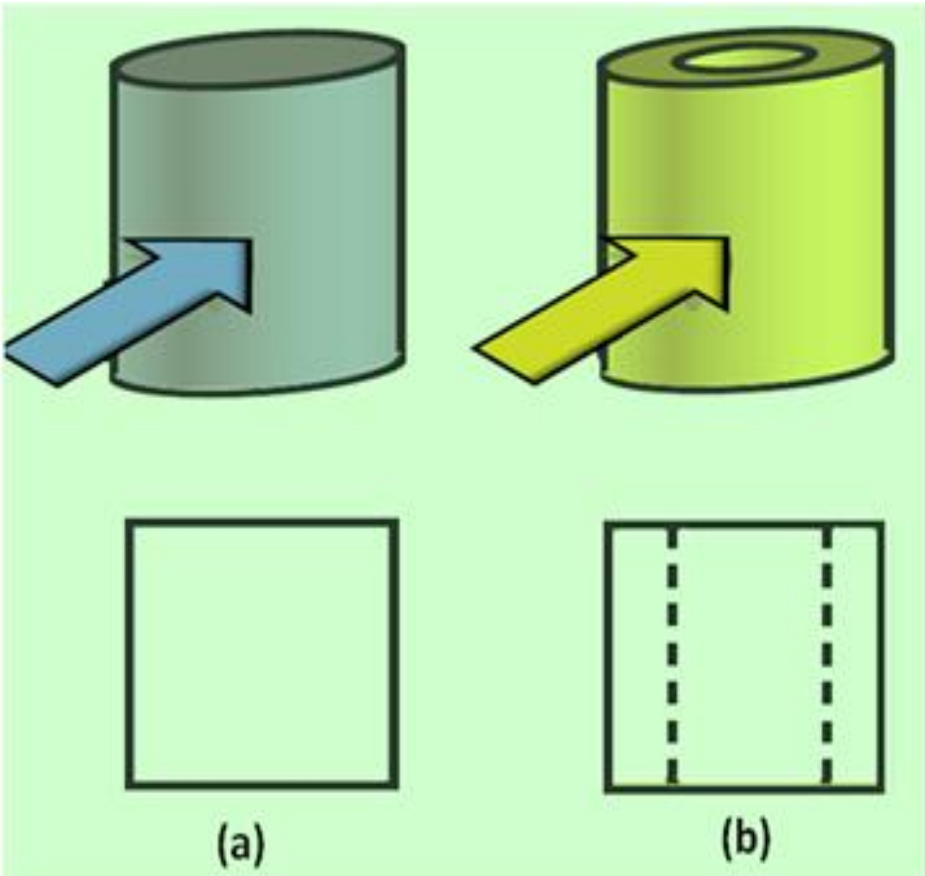


Figure 2 shows the pictorial view and front view of (a) a hollow cylindrical object and (b) solid cylindrical object.

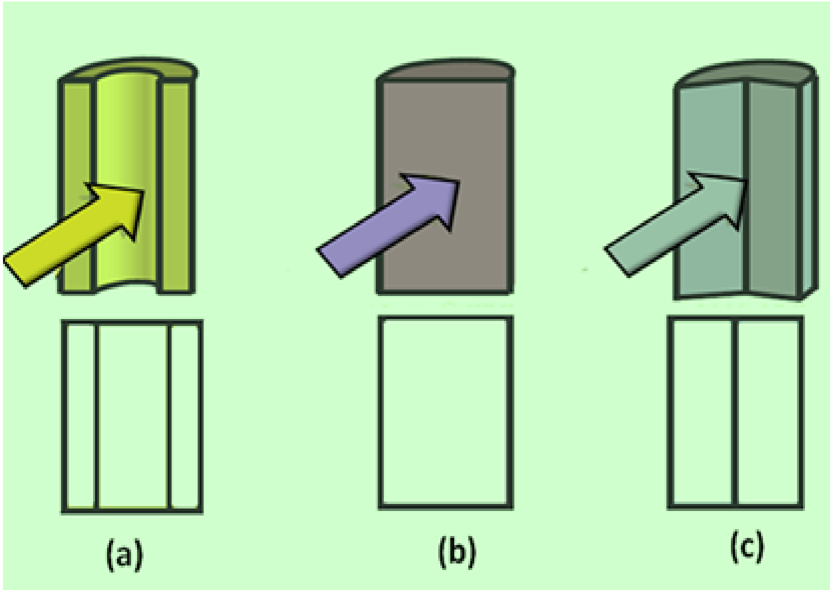


Figure 3 shows the pictorial view and front view of sectioned part of (a) a hollow cylindrical object (b) solid cylindrical object and (c) solid cylinder split in to two unequal parts.

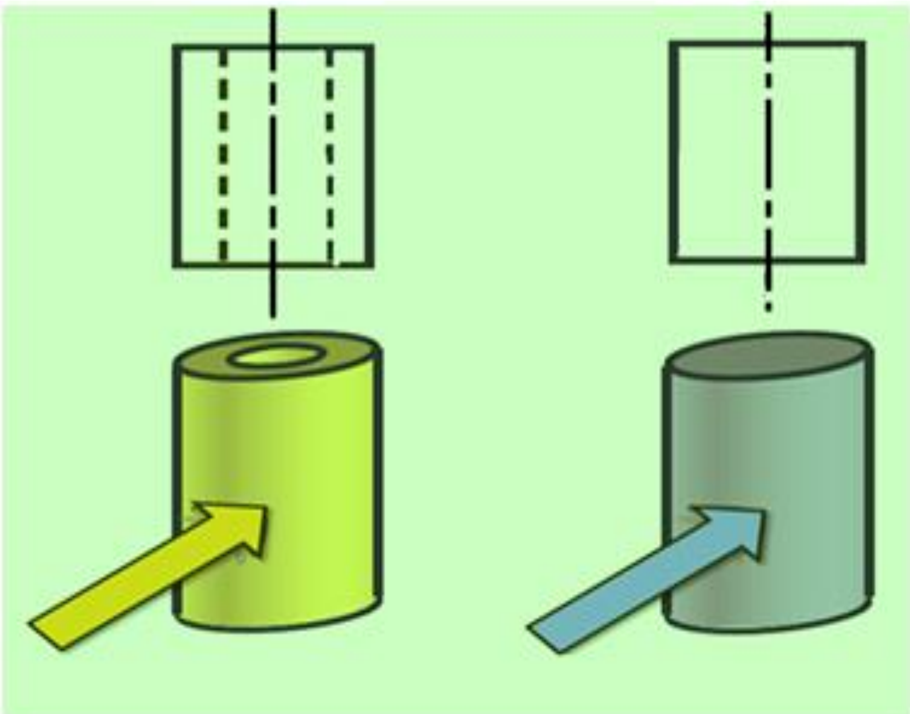


Figure 4 shows the centre lines for cylindrical objects

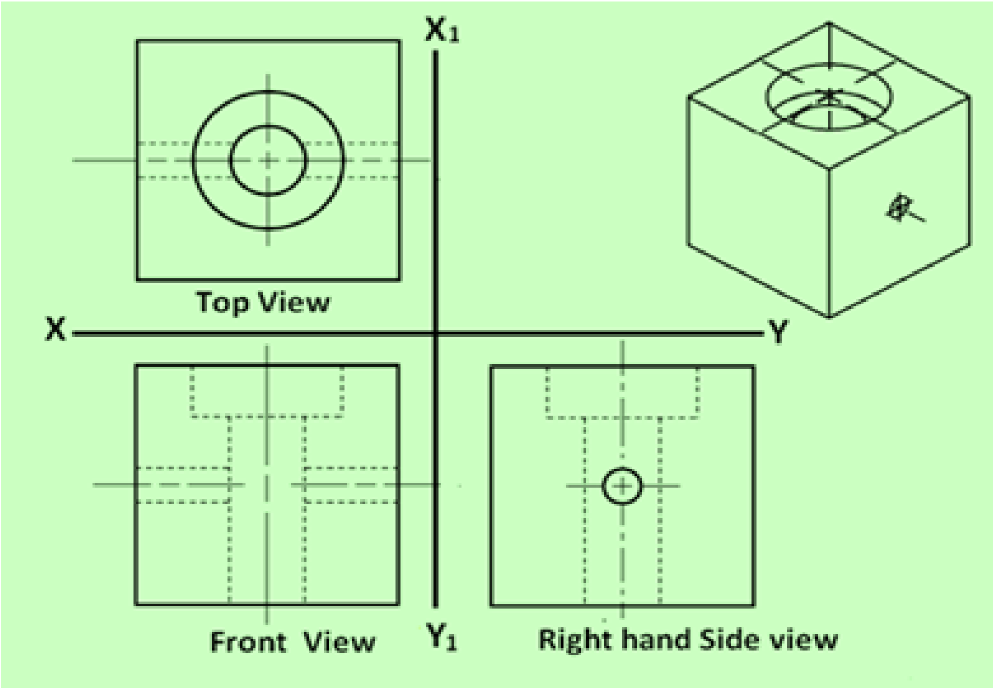


Figure 5. Showing TV, FV and RHSV of an object showing the three types of lines mentioned above. The pictorial view of the object is shown at the top hight hand side.

Conventions used for lines

In orthographic projections, many times different types of lines may fall at the same regions. In such cases, the following rules for precedence of lines are to be followed:

- *Visible lines* take precedence over all other lines
- *Hidden lines* take precedence over center lines
- *Center lines* have lowest precedence

When a visible line and a hidden line are to be drawn at the same area, It will be shown by the visible line only and no hidden line will be shown. Similarly, in case of hidden line and centre line, onlu hidden line will be shown. In such case, the centre line will be shown only if it is extending beyond the length of the hidden line.

Intersecting Lines in Orthographic Projections

The conventions used when different lines intersect is shown in figure - 6(a) & (b).

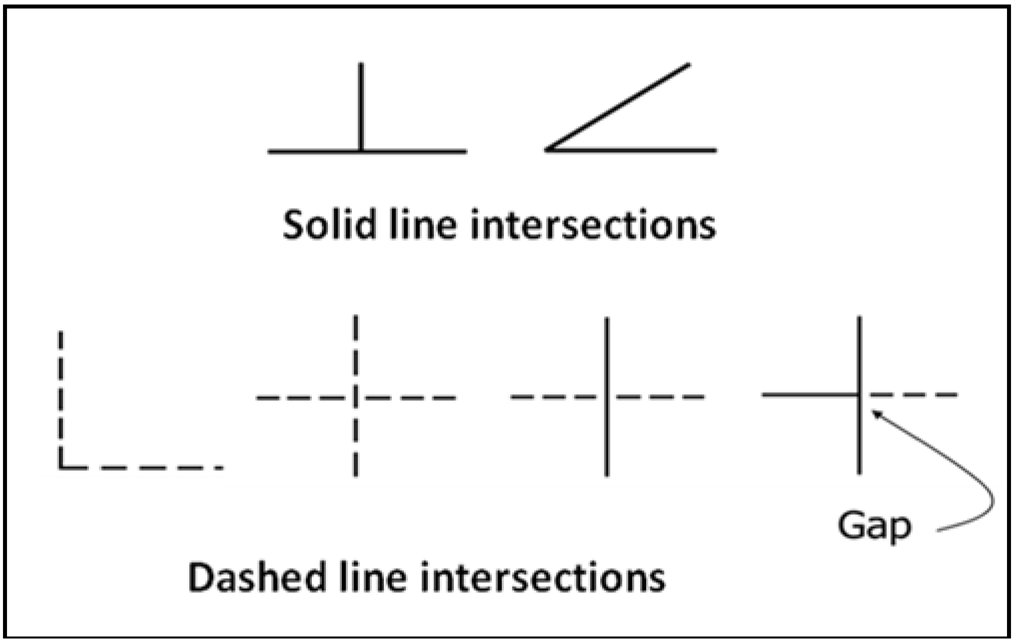


Figure 6(a): The conventions practiced for intersection lines.

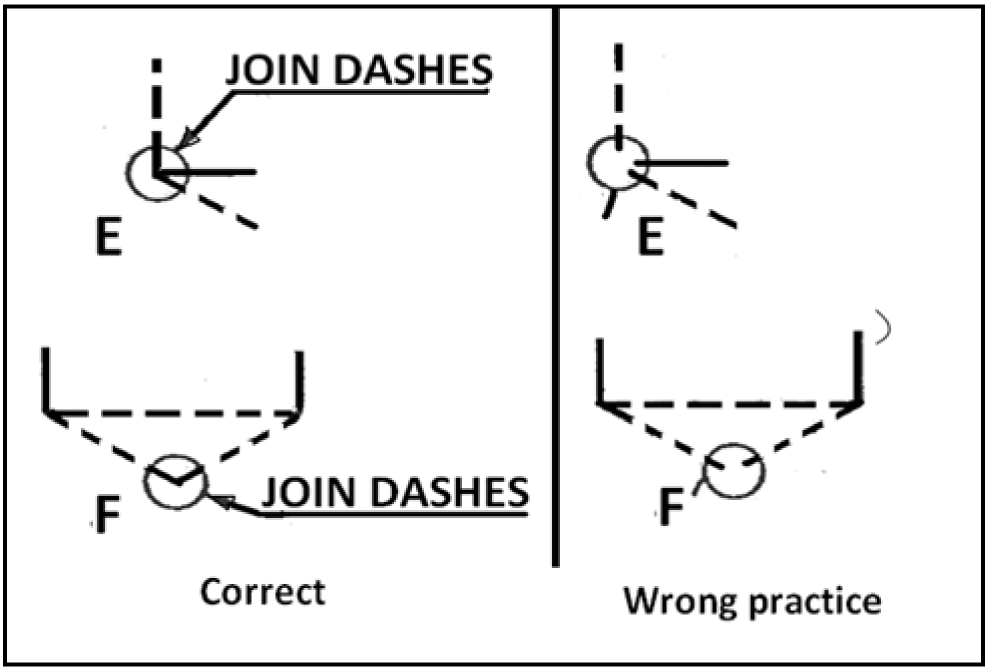
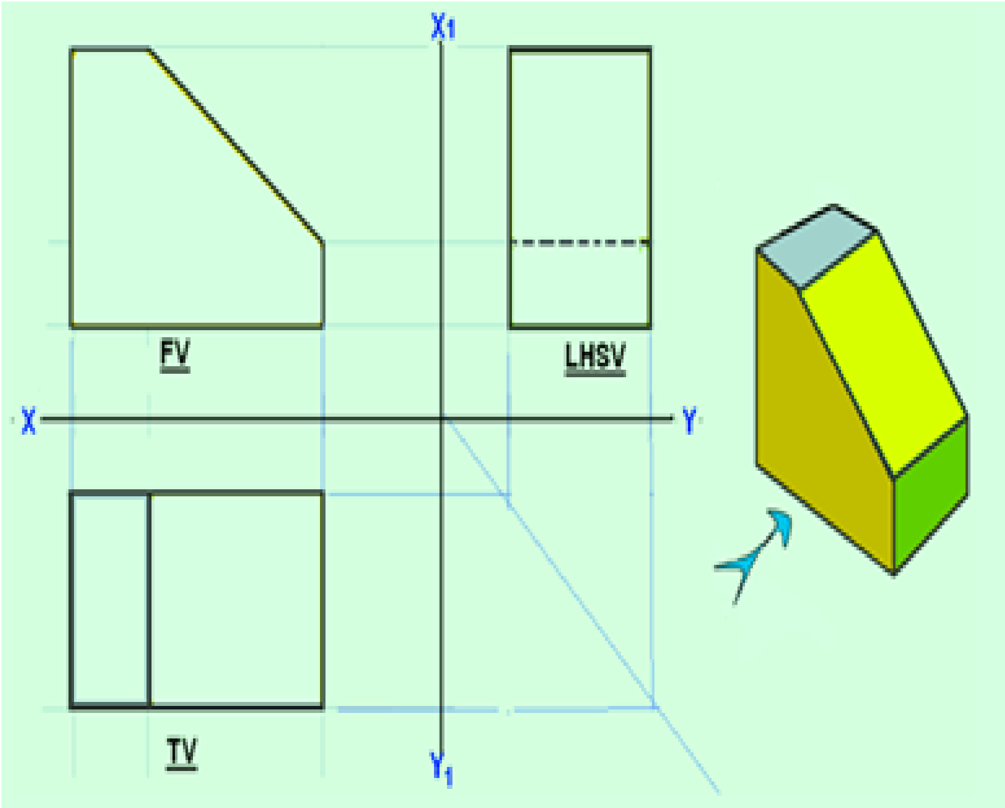
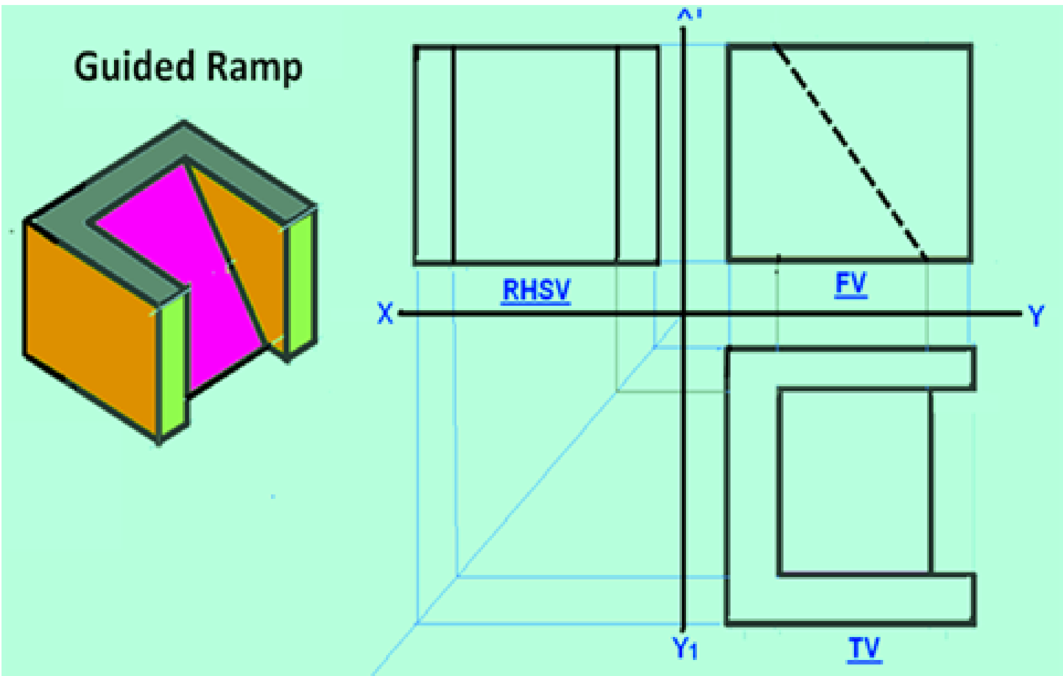


Figure 6(b): The conventions practiced for intersection lines.

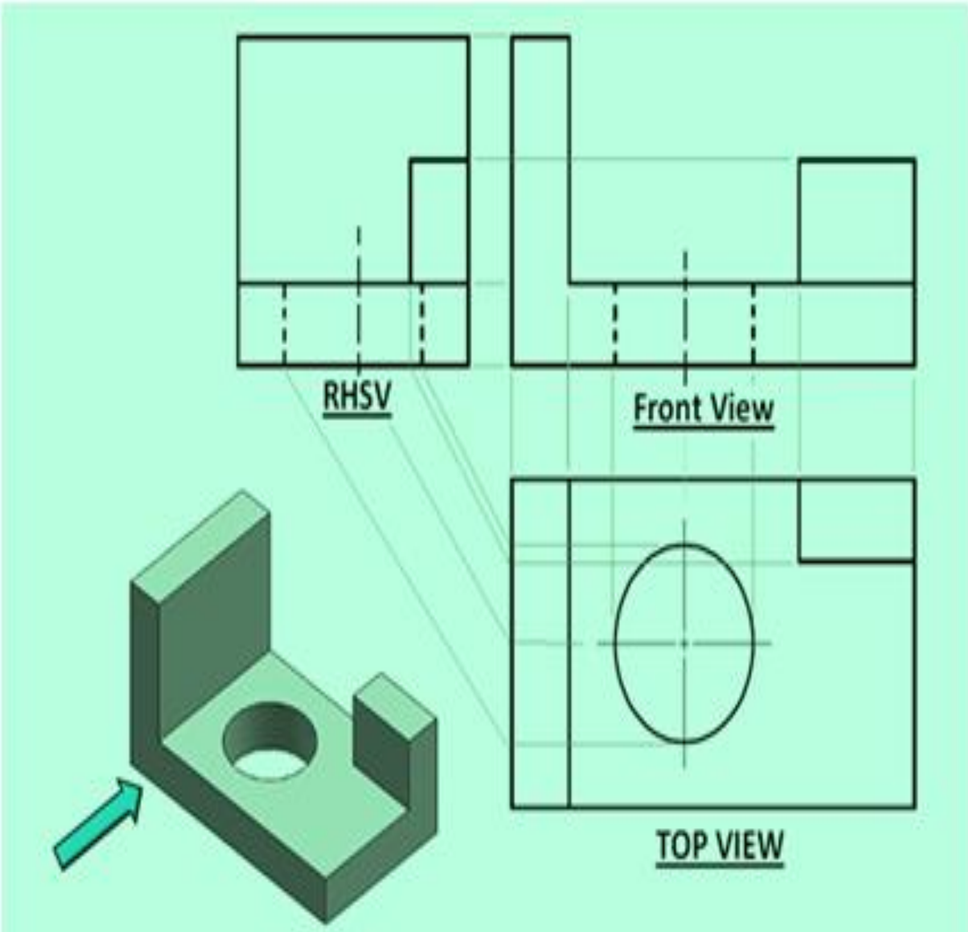
- Some orthographic projections of solids showing the different lines and their precedence are shown as examples below.
- The 3-D view of the respective objects is also shown in the figures with the direction of arrow representing the line of sight in the front view.
A few examples of the projections showing the conventions in drawing are presented below.



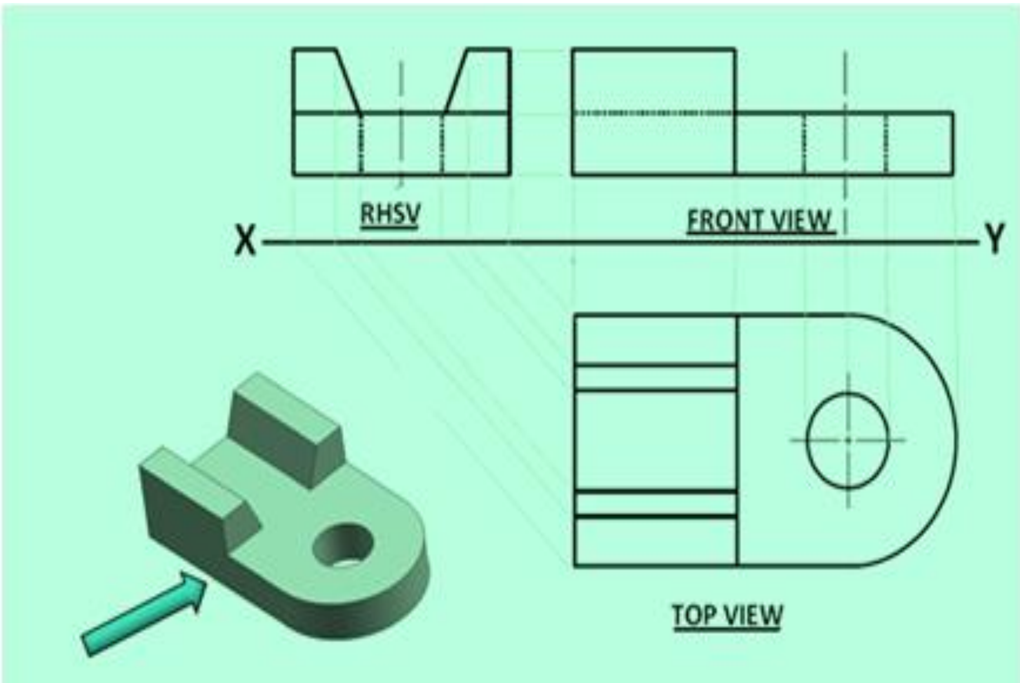
Example 1



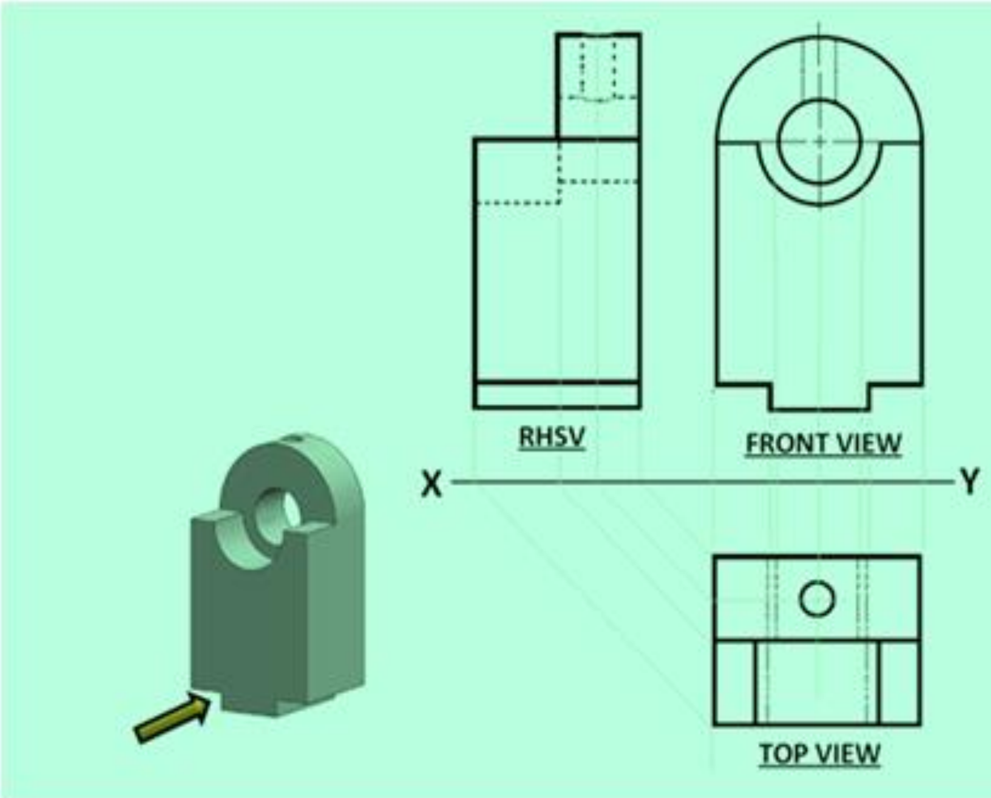
Example 2



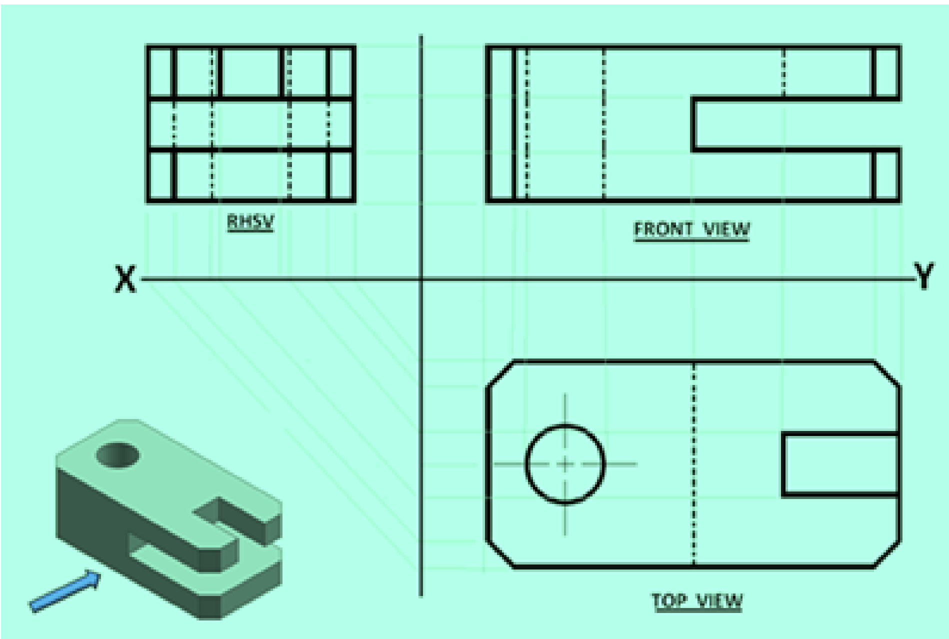
Example 3



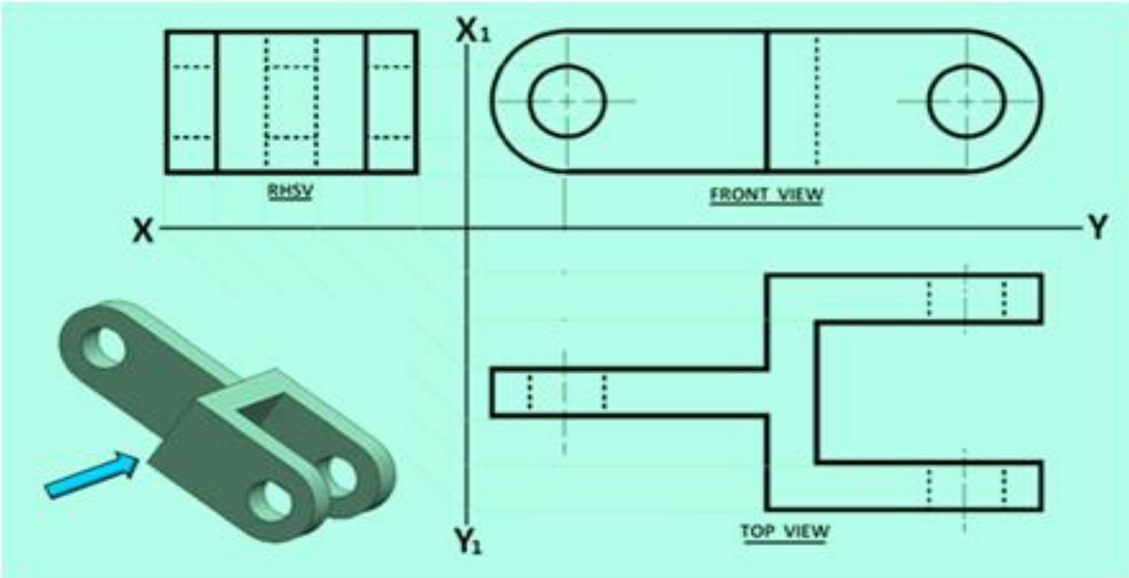
Example 4



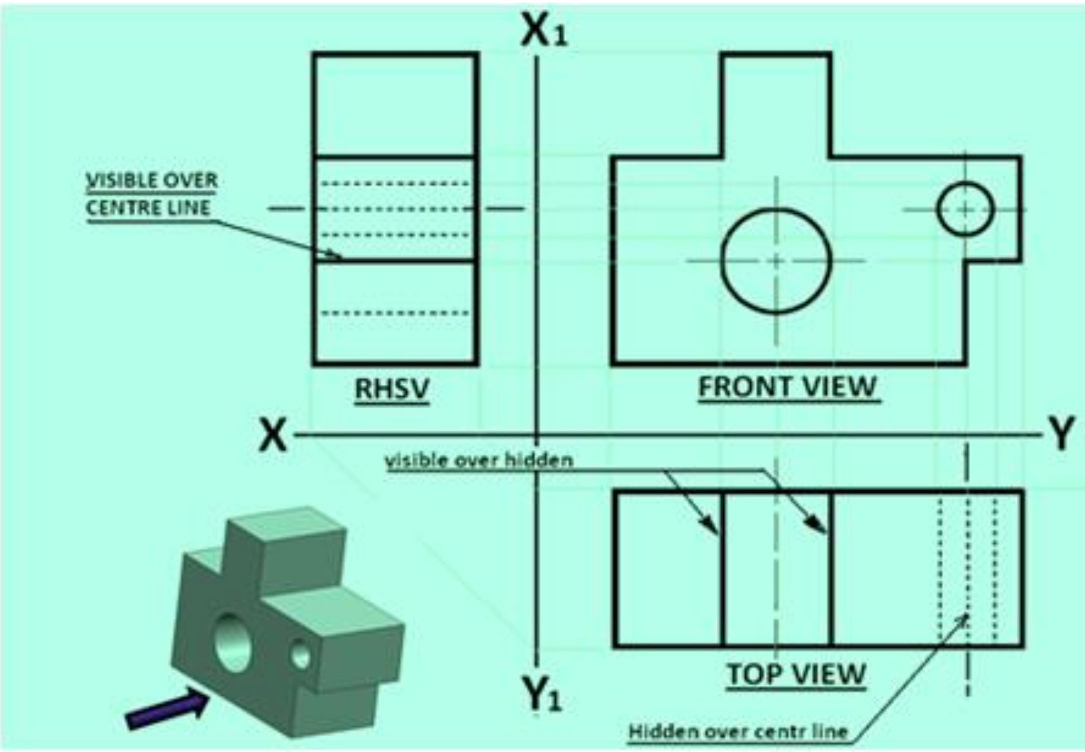
Example 5



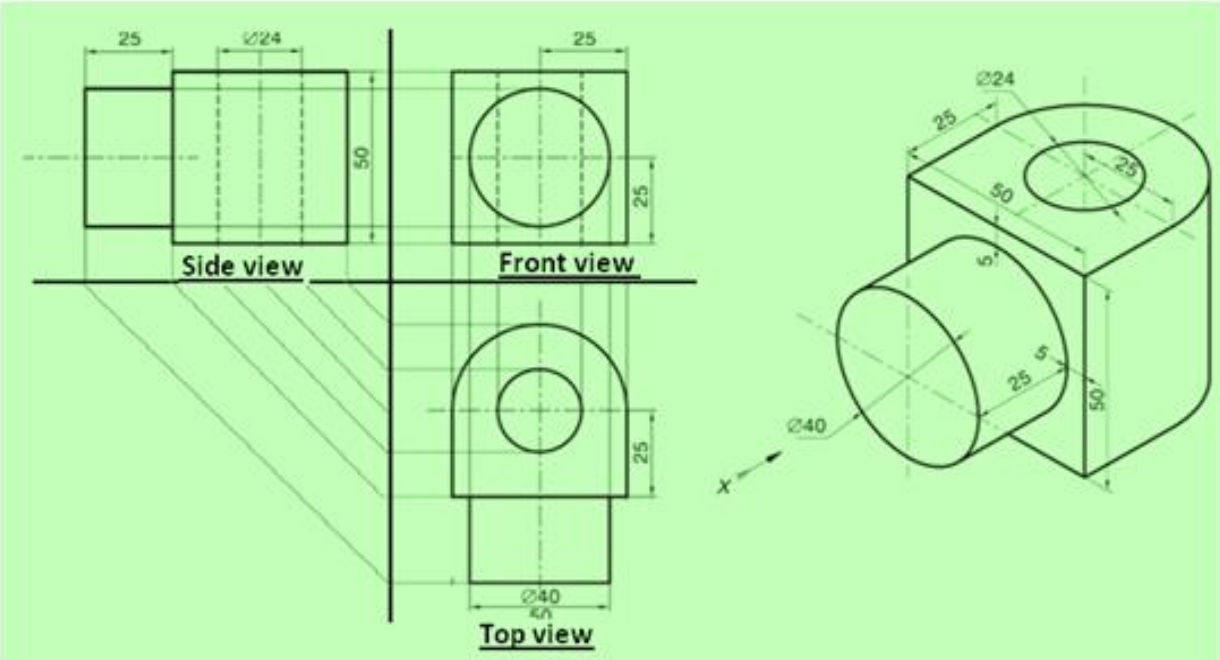
Example 6



Example 7



Example 8 (application of Precedence rule)



Example 9 (Objects with circular features : holes, flanges, etc)

4.2 Isometric Projections

- An isometric projection is a true representation of the isometric view of an object.
- An isometric view of an object is created by rotating the object 45° about a vertical axis, then tilting the object (see figure 7, in this case, a cube) forward until the body diagonal (AB) appears as a point in the front view.
- The angle the cube is tilted forward is 35° 16′. The 3 axes that meet at A, B form equal angles of 120° and are called the isometric axes.
- Each edge of the cube is parallel to one of the isometric axes. Line parallel to one of the legs of the isometric axis is an isometric line. Planes of the cube faces & all planes parallel to them are isometric planes

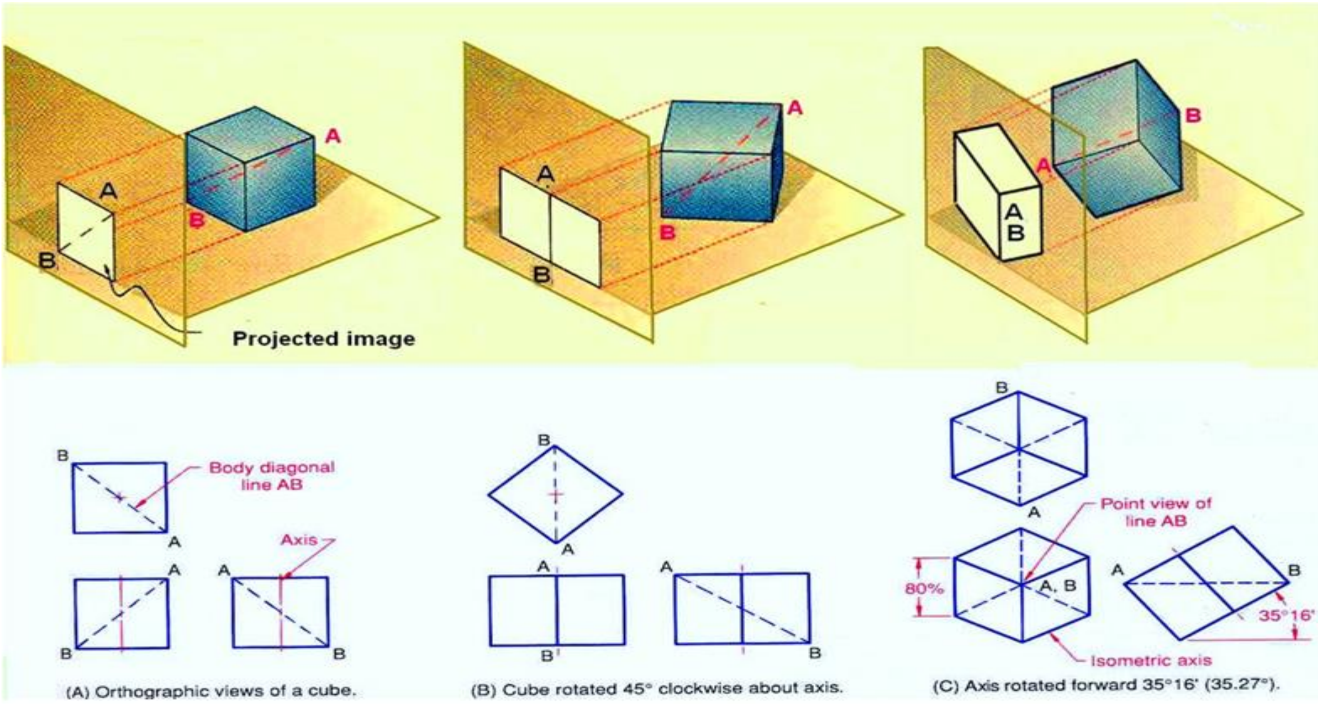


Figure 7. Rotation of the object with respect to the projection plane result in isometric projection.

- The forward tilt of the cube causes the edges and planes of the cube to become shortened as it is projected onto the picture plane.
- The lengths of the projected lines are equal to the cosine of 35° 16′, or 0.81647 times the true length. In other words, the projected lengths are approximately 80% of the true lengths.
- A drawing produced using a scale of 0.816 is called an *isometric projection* and is a true representation of the object.
- However, if the drawing is produced using full scale, it is called an isometric drawing, which is the same proportion as an isometric projection, but is larger by a factor of 1.23 to 1.
- Figure 8. Illustrates the isometric projection and isometric drawing.
- Isometric drawings are almost always preferred over isometric projection for engineering drawings, because they are easier to produce.
- An isometric drawing is an axonometric pictorial drawing for which the angle between each axis equals 120° and the scale used is full scale.

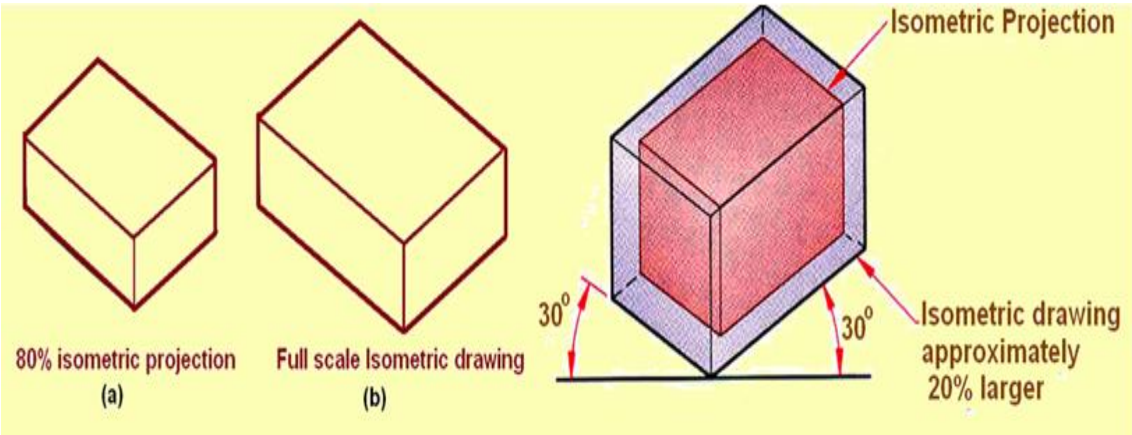


Figure 8 Shows the (a) isometric projection and (b) isometric drawing (or view) of a cuboid.

- While drawing isometric projection, an Isometric scale is to be constructed for convenience and all the measurements are to be taken from this scale.
- As shown in figure 9, isometric scale is produced by positioning a regular scale at 45 ° to the horizontal and projecting lines vertically to a 30° line.

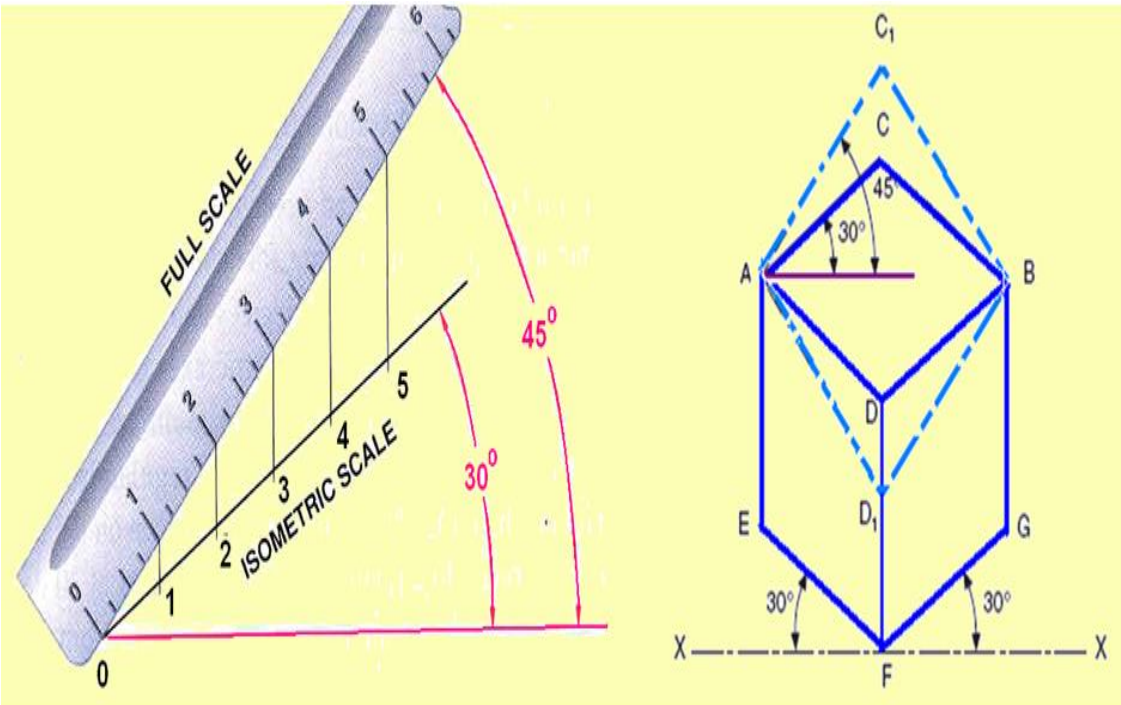


Figure 9. illustrates the construction of an isometric scale.

$$\text{Isometric scale} = \left(\frac{\text{Isometric length}}{\text{True length}}\right) = \frac{\cos 45^{o}}{\cos 30^{o}} = \frac{1}{\sqrt{2}} + \frac{\sqrt{3}}{2} = 0.8165$$

i.e. isometric length = 82% (approximately)

- Isometric axes can be positioned in a number of ways to create different views of the same object.
- Figure 10(a) is a regular isometric, in which the viewpoint is looking down on the top of the object.
- In a regular isometric, the axes at 30° to the horizontal are drawn upward from the horizontal.
- In the reversed axis isometric, as shown in figure 10(b), the viewpoint is looking up on the bottom of the object, and the 30° axes are drawn downward from the horizontal.
- Figure 10(c)&(d) show the long axis isometric, where the viewpoint is looking from the right or from the left of the object, and one axis is drawn at 60 ° to the horizontal. While drawing the Isometric view, first the view point will have to be decided for obtaining the maximum technical information.

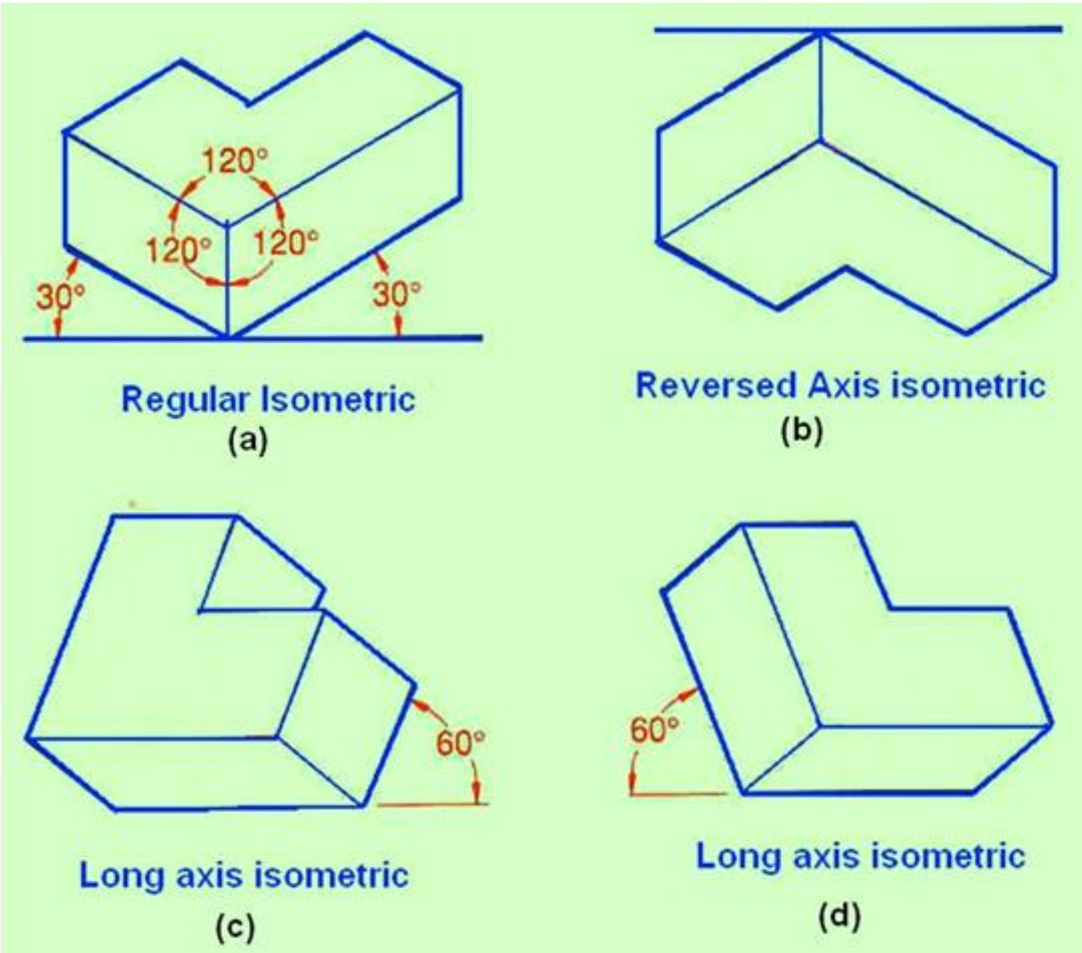


Figure 10. shows different isometric axis depending on the direction of view point.

Isometric axes and non-isometric axes

- Figure 11(a) illustrates the isometric axes, non-isometric axes and isometric planes. In an isometric drawing, true length distances can only be measured along isometric lines. i.e. lines that run parallel to any of the isometric axes.
- Any line that does not run parallel to an isometric axis is called a non-isometric line. Non-isometric lines include inclined and oblique lines and cannot be measured directly. Instead they must be created by locating two end points.

- Figure 11(b) is an isometric drawing of a cube.
- The three faces of the isometric cube are isometric planes, because they are parallel to the isometric surfaces formed by any two adjacent isometric axes.
- Planes that are not parallel to any isometric plane are called non-isometric planes sa shown in figure 11(a).

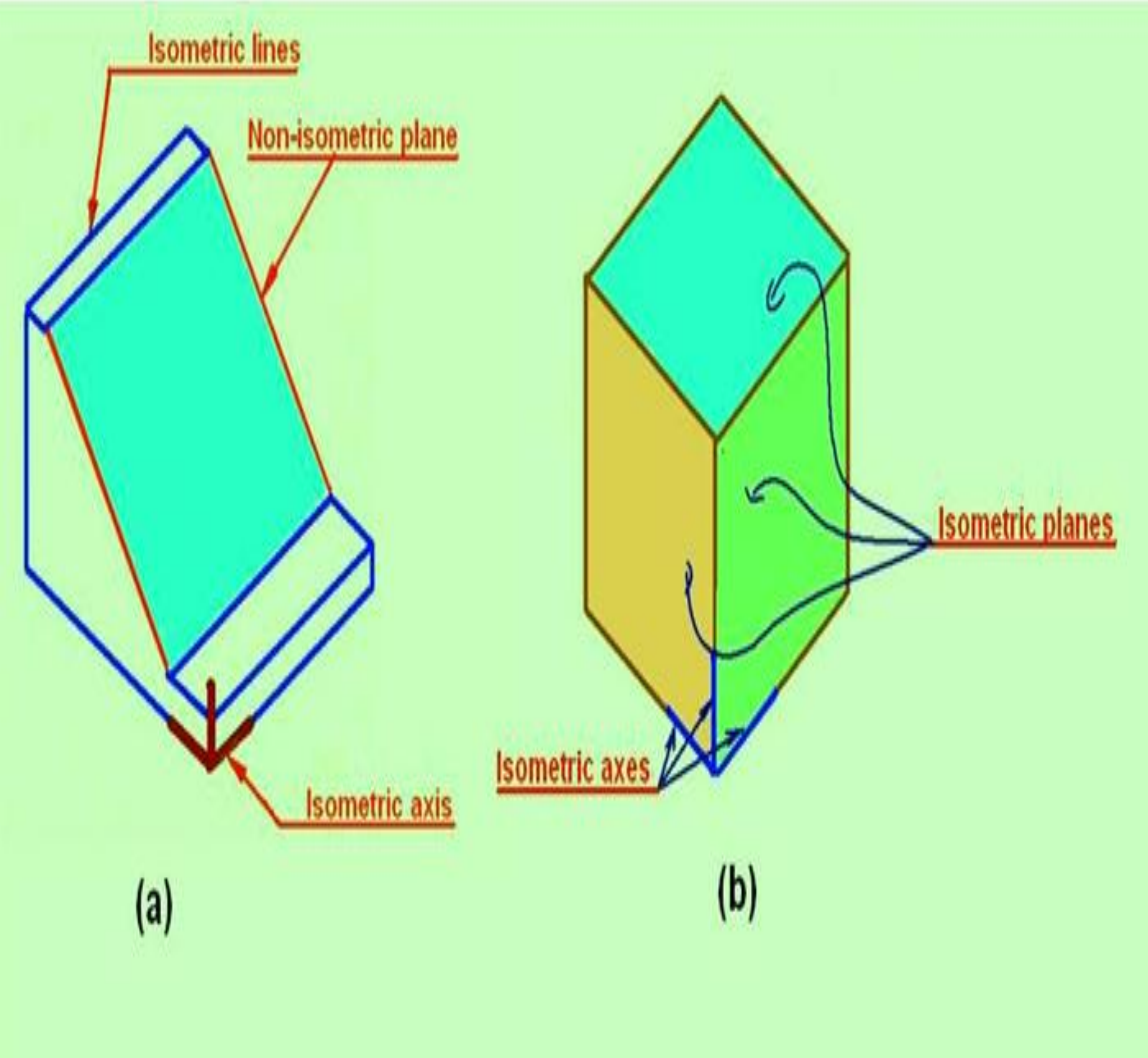


Figure 11. showing isometric axes, non-isometric axes and isometric planes.

Hidden Lines, Center Lines and Dimensions

- In isometric drawings, hidden lines are omitted unless they are absolutely necessary to completely describe the object.
- Most isometric drawings will not have hidden lines.
- To avoid using hidden lines, choose the most descriptive viewpoint.
- However, if an isometric viewpoint cannot be found which clearly depicts all the major features, hidden lines may be used. eg. Figure 12(a).
- Centerlines are drawn only for showing symmetry or for dimensioning. Normally, centerlines are not shown, because many isometric drawings are used to communicate to non-technical people and not for engineering purposes.

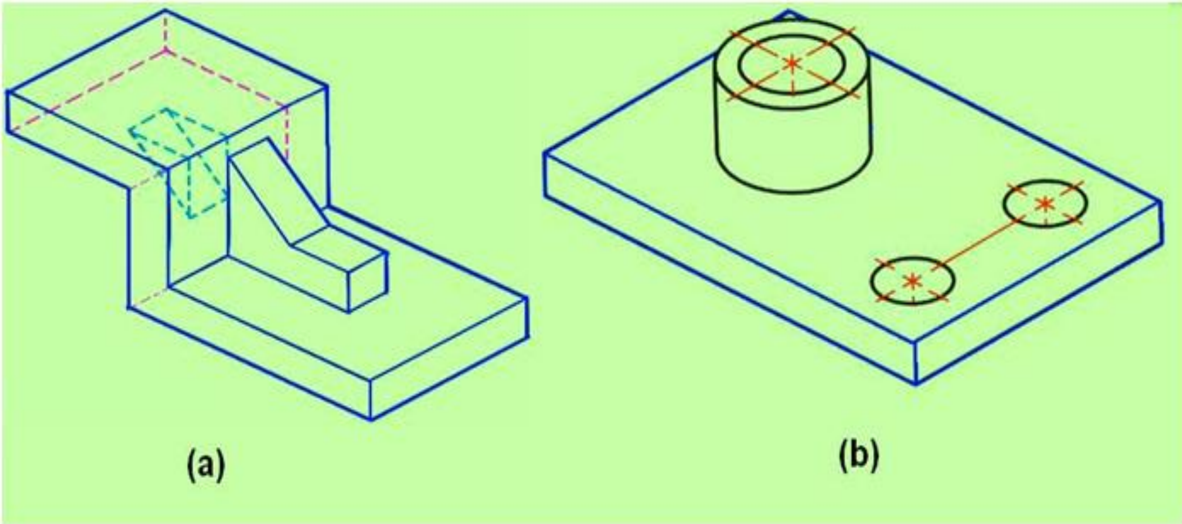


Figure 12 showing hidden lines and centre lines.

- Dimension lines, extension lines, and lines being dimensioned shall lie in the same plane..
- All dimensions and notes should be unidirectional, reading from the bottom of the drawing upward and should be located outside the view whenever possible.
- The texts are read from the bottom, using horizontal guidelines as shown in Figure 13.

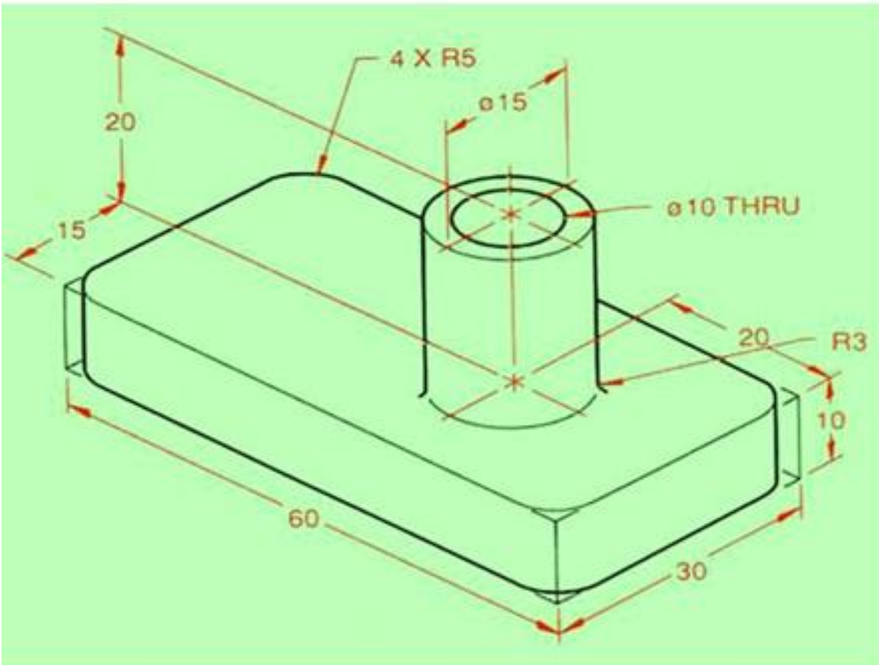


Figure 13 showing the procedure of using dimension lines, extension lines and text.

Isometric view of some standard shapes

1.Square

- Consider a square ABCD with a 30 mm side shown in Fig14. If the square lies in the vertical plane, it will appear as a rhombus with a 30 mm side in isometric view as shown in Fig.14 (a) or 14(b), depending on its orientation, i.e., right-hand vertical face or left-hand vertical face.

- If the square lies in the horizontal plane (like the top face of a cube), it will appear as in Fig.14(c). The sides AB and AD, both, are inclined to the horizontal reference line at 30°.

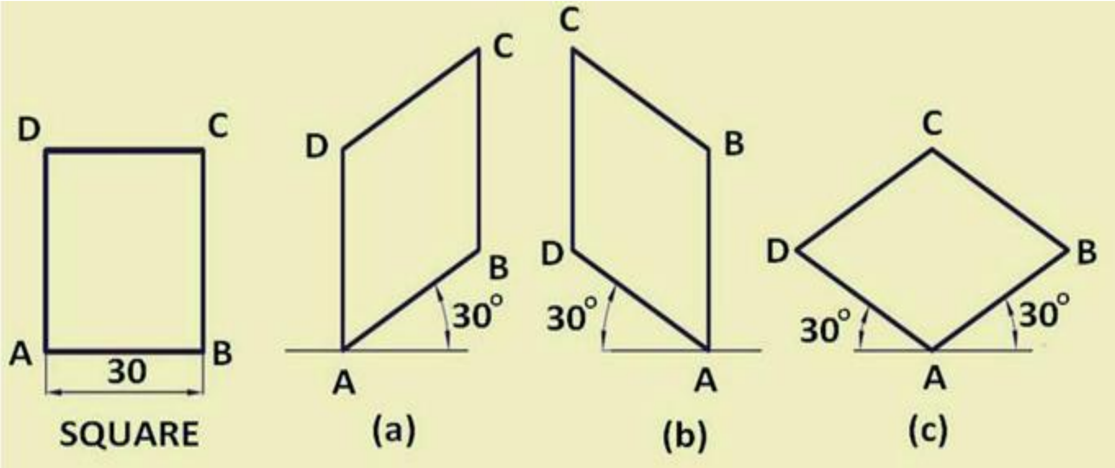


Figure 14. Isometric views of a square.

2.Rectangl*e*

A rectangle appears as a parallelogram in isometric view as shown in figure 15. Three versions are possible depending on the orientation of the rectangle, i.e., right-hand vertical face, left-hand vertical face or horizontal face.

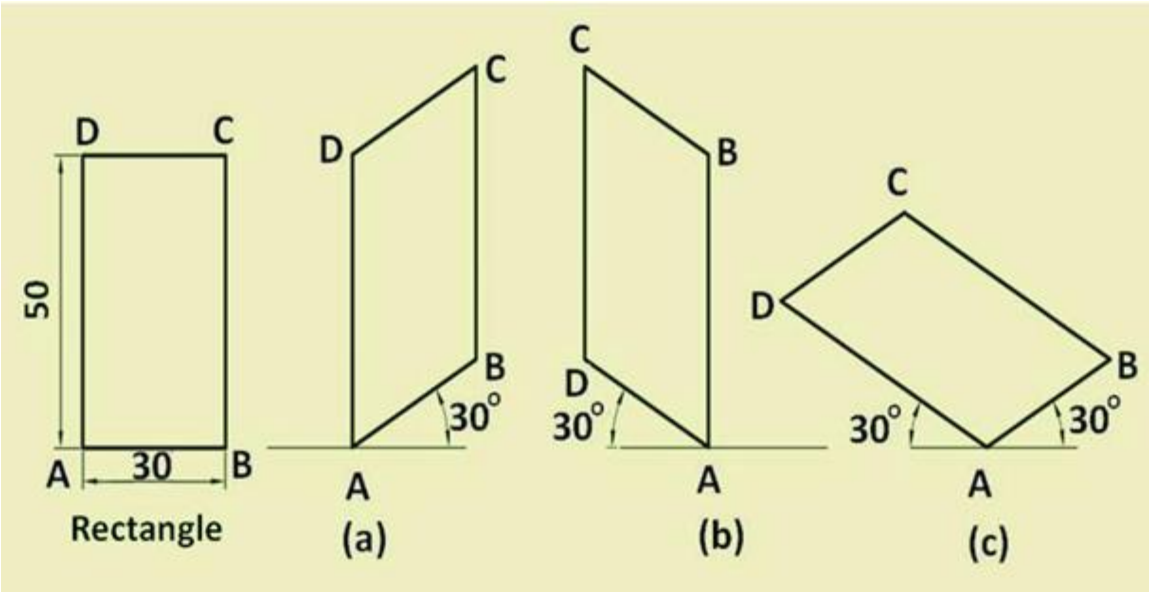


Figure 15. Isometric views of a rectangle.

3.Triangle

- A triangle of any type can be easily obtained in isometric view as explained below. First enclose the triangle in rectangle *ABCD*. Obtain parallelogram *ABCD* of the rectangle as shown in Fig. 16(a) or (b) or (c).

- Then locate point 1 in the parallelogram such that *C*–1 in the parallelogram is equal to *C*–1 in the rectangle. *A*–*B*–1 represents the isometric view of the triangle.

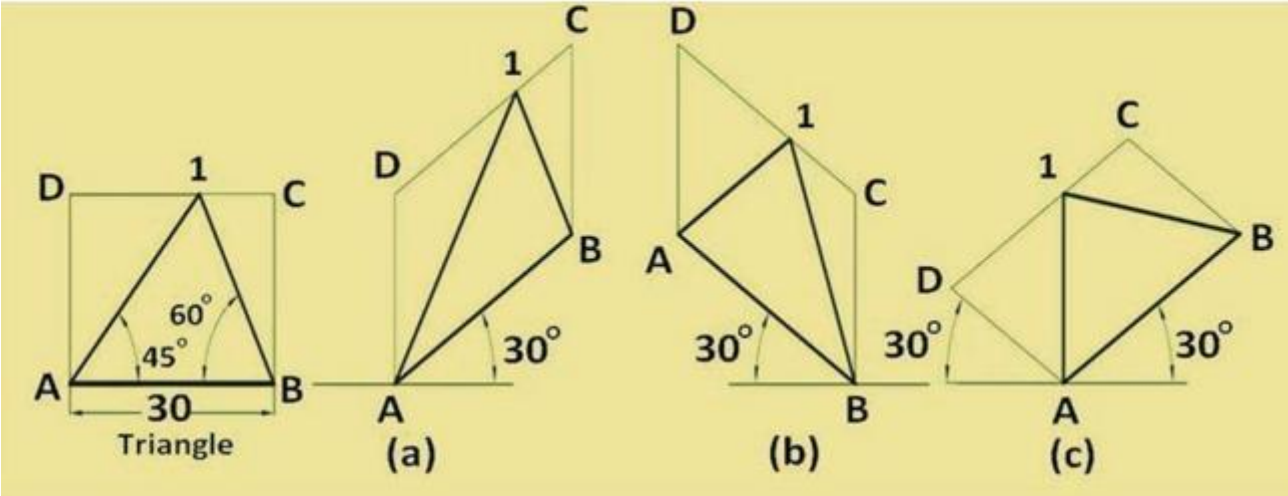


Figure 16. Method of obtaining the isometric views of a triangle.

4.Pentagon

- Enclose the given pentagon in a rectangle and obtain the parallelogram as in Fig. 17 (a) or (b) or (c).
- Locate points 1, 2, 3, 4 and 5 on the rectangle and mark them on the parallelogram.
- The distances *A*–1, *B*–2, *C*–3, *C*–4 and *D*–5 in isometric drawing are same as the corresponding distances on the pentagon enclosed in the rectangle since the edges of the rectangle are isometric axes.

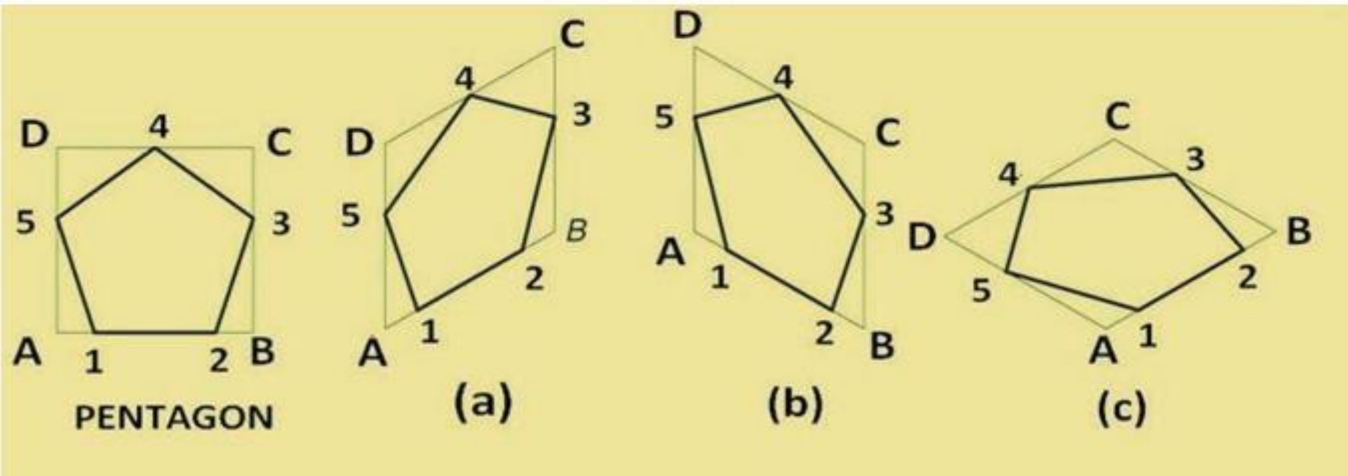


Figure 17. Method of obtaining the isometric views of a pentagon.

5.Circle

- The isometric view or isometric projection of a circle is an ellipse. It is obtained by using four-centre method explained below and illustrated in Figure 18.

- ***Four-Centre Method***: First, enclose the given circle into a square *ABCD*. Draw rhombus *ABCD* as an isometric view of the square. Join the farthest corners of the rhombus, i.e., *A* and *C*. Obtain midpoints 3 and 4 of sides *CD* and *AD* respectively.
- Locate points 1 and 2 at the intersection of *AC* with *B*–3 and *B*–4 respectively. Now with 1 as a centre and radius 1–3, draw a small arc 3–5. Draw another arc 4–6 with same radius but 2 as a centre. With *B* as a centre and radius *B*–3, draw an arc 3–4. Draw another arc 5–6 with same radius but with *D* as a centre.

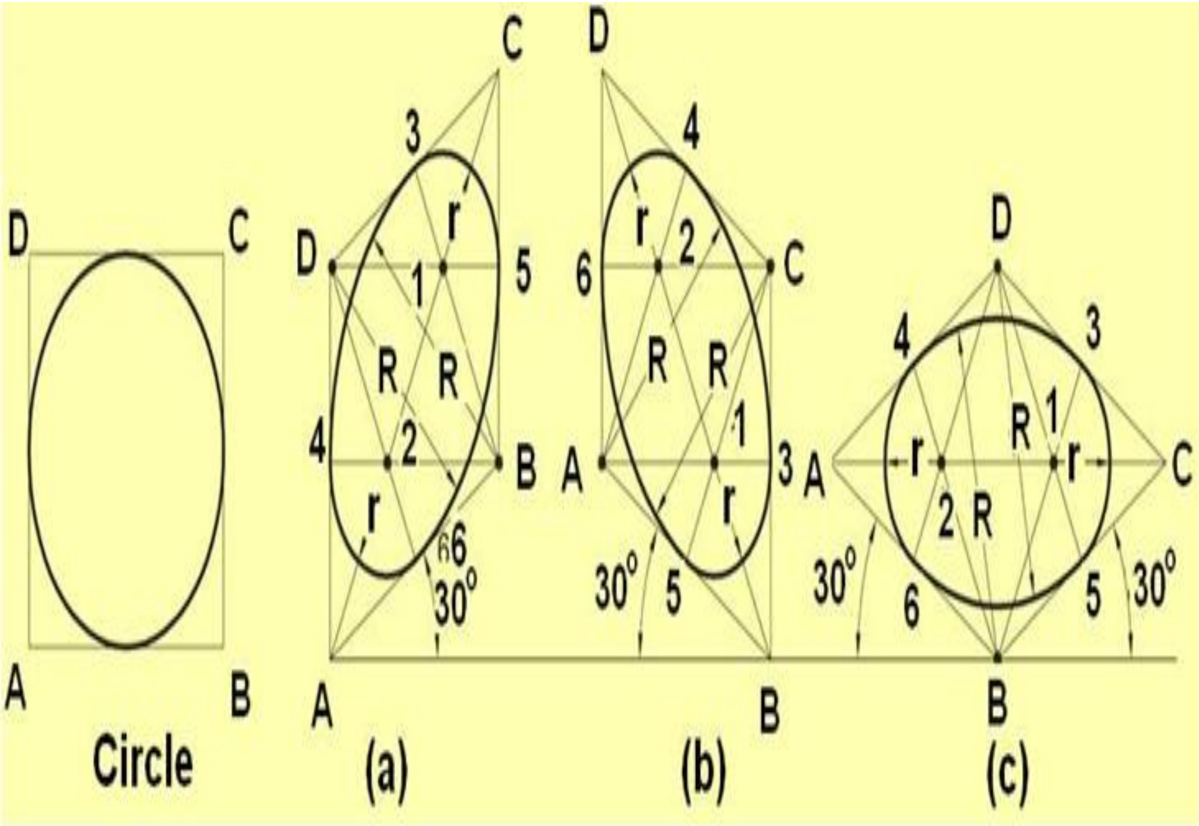


Figure 18. Method of obtaining the isometric views of a circle by four-centre method.

6.Isometric view of irregular Shape

- The method of drawing the isometric view of an irregular shape 1–2–3–4–5–6–7 is illustrated in Figure 19.
- First the figure is enclosed in a rectangle. The parallelogram is obtained in isometric for the rectangle as shown.
- The distances B–2, D–2, C–3, E–3, G–4, F–4, H–5, H–6 and A–7 has the same length as in original shape since they are along the isometric axis.
- The points 1 to 7 are located by travelling along the isometric lines. After locating the points, the points are joined for lines which lie along non-isometric lines viz. 1-2, 2-3, 3-G, 6-5, 7-6.

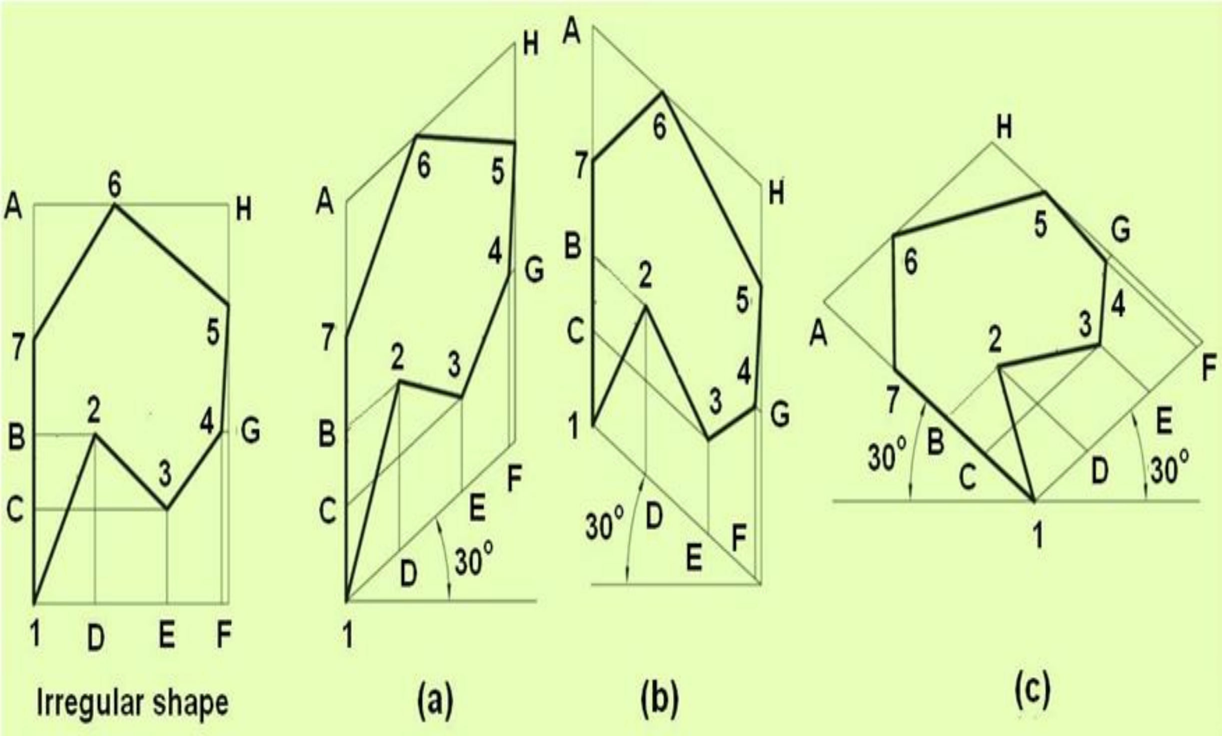


Figure 19. Method of obtaining the isometric views of an irregular shape.

Isometric Projections Drawing for Solids

The most convenient method of drawing the isometric view of any solid object is by the boxing method. In this the object is considered to be placed in a rectangular box having dimensions with maximum dimensions of the object along the three axes. The edges of the rectangular box are the isometric axes and the surfaces of the rectangular box are the isometric planes.

The four basic steps for creating an isometric drawing are:

1. Positioning the object. Determine the isometric viewpoint that clearly depicts maximum features of the object
2. Once the object is positioned and the view point is decided, draw the isometric axes which will produce that view-point.
3. Construct isometric planes, using the overall width (W), height (H), and depth (D) of the object, such that the object will be totally enclosed in a box.
4. Locate details on the isometric planes. Darken all visible lines, and eliminate hidden lines unless absolutely necessary to describe the object.

Figure 20 Shows the multi-view drawing of an object. The figure illustrates the isometric view of the object while positioning using the regular isometric and reverse isometric viewpoints. For this object, regular isometric will provide maximum information regarding the object compared to the reverse isometric.

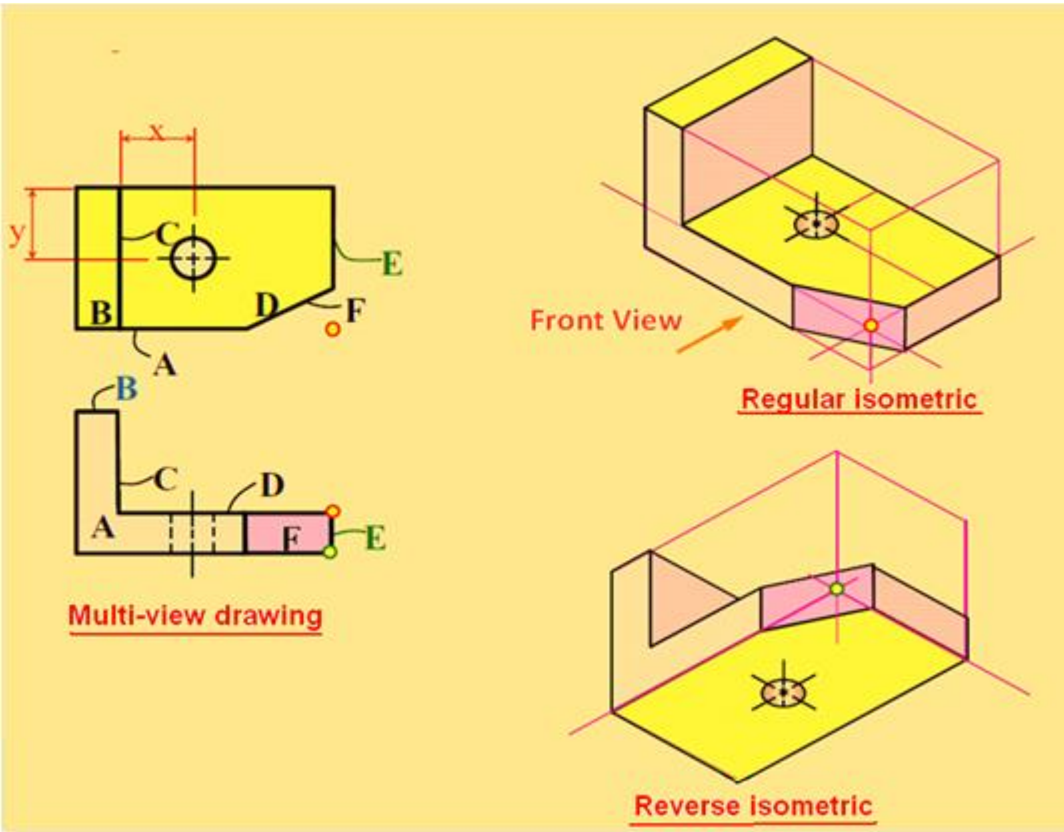


Figure 20. The isometric views using regular isometric and reverse isometric view points.

The step wise procedure of drawing of isometric views of objects are presented in the subsequent examples.

Example -1: Drawing isometric planes
The step wise procedure for drawing isometric view of an object having isometric planes only are shown in figure 21.

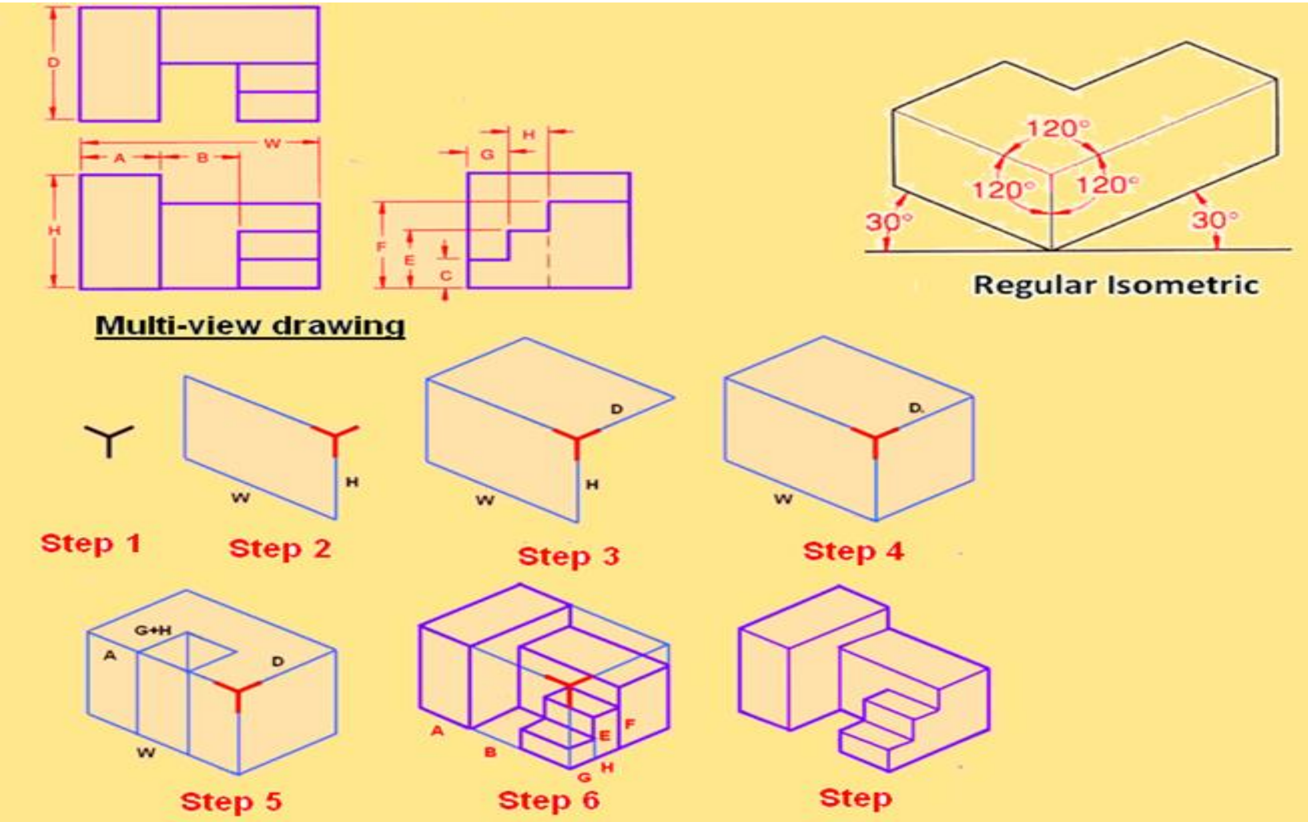


Figure 21. Step wise procedure of drawing the isometric view of the object

Step 1. Determine the desired view of the object. Here the object will be viewed from above (regular isometric). The isometric axes is then drawn as shown in step-1.
Step 2. Construct the front isometric plane using W and H dimensions. Width dimensions are drawn along 30o lines from the horizontal. Height dimensions are drawn as vertical lines.
Step 3. Construct the top isometric plane using the W and D dimensions. Both W and D dimensions are drawn along 30o lines from the horizontal.
***Step* 4.** Construct the right side isometric plane using D and H dimensions. Depth dimensions are drawn along 30o lines and height dimensions are drawn as vertical lines.
***Step* 5.** Transfer some distances for the various features from the multi-view drawing to the isometric lines that make up the isometric rectangle on the front and top planes of the isometric box. e.g. distance A is measured from the multi-view drawing./ It is then transferred along the width line in the front plane of the isometric rectangle. Draw the details of the block by drawing isometric lines between the points transferred from the multi-view drawing. e.g., the notch is taken out of the block by locating its position on the front and the top planes of the isometric box.
***Step* 6.** Transfer the remaining features from the multi-view drawing to the isometric drawing. Block in the details by connecting endpoints of the measurements taken from the multi-view drawing.
***Step* 7.** Darken all visible lines and erase or lighten the construction lines to complete the isometric drawing of the object

Example 2. Drawing Non-Isometric Lines

- Non-isometric lines will be the edges of inclined or oblique planes of an object as represented in a multi-view drawing.
- It is not possible to measure the length or angle from an inclined or oblique line in a multi-view drawing and then transferring these distances to draw the line in an isometric drawing.
- Instead, non-isometric lines must be drawn by locating the two end points of the lines on isometric lines and then connecting these end points with a line. The process used is called offset measurement, which is a method of locating one point by projecting another point. Figure 22. Illustrates the step wise procedure of drawing the isometric view of an object having inclined or oblique planes.

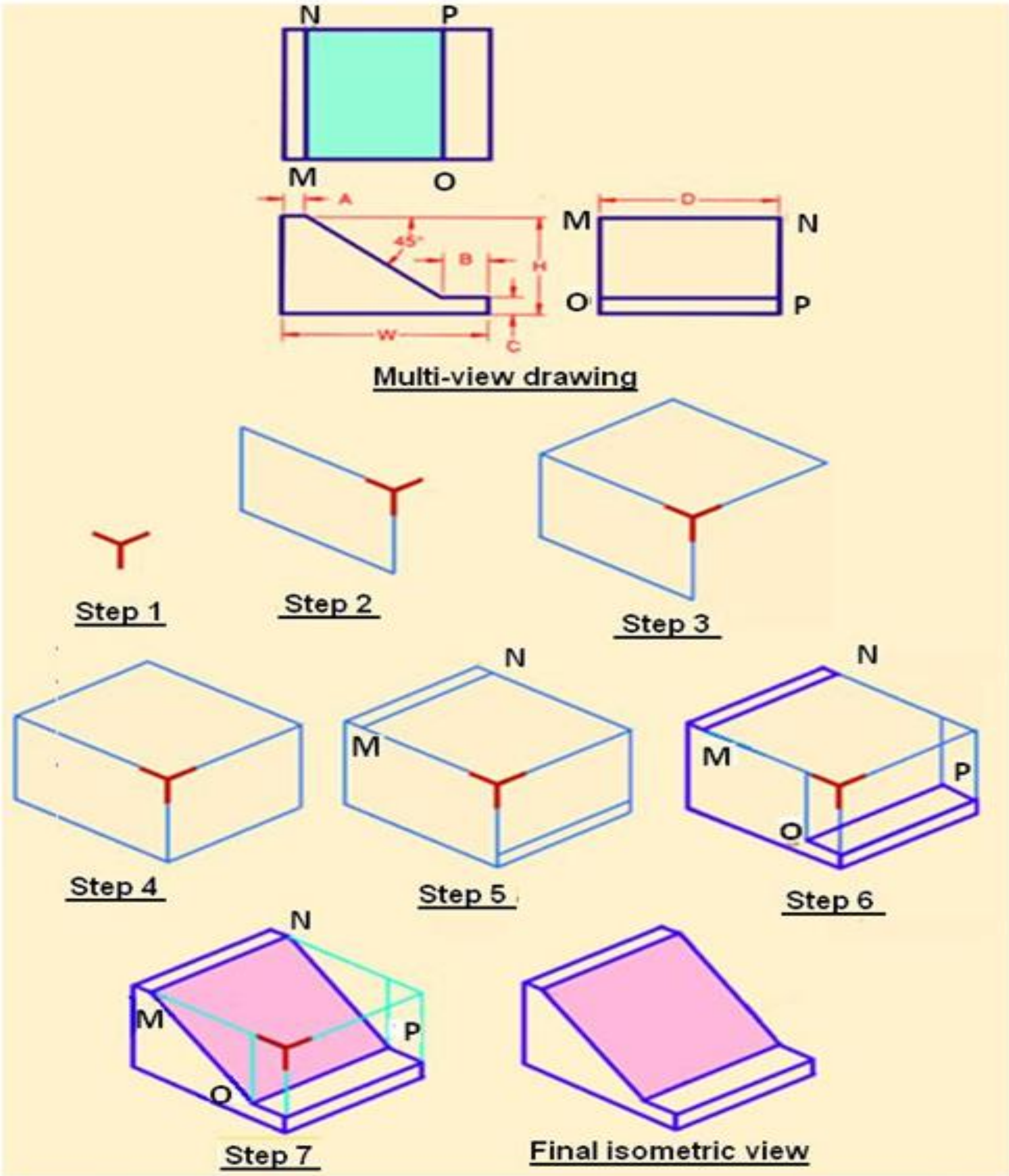


Figure 3. Step wise procedure of drawing the isometric view of the object having non-isometric planes.

Step 1. Determine the desired view of the object, then draw the isometric axes. Here it is preferred that the object be viewed from above, and the axis shown in Figure A is used.
Step 2. Construct the front isometric plane using W and H dimensions.
Step 3. Construct the top isometric plane using the W and D dimensions.
Step 4. Construct the right side isometric plane using D and H dimensions.
Step 5. Transfer the distances for A and C from the multi-view drawing to the top and right side isometric rectangles. Draw line MN across the top face of the isometric box. Draw an isometric construction line from the endpoint marked for distance C. This projects the distance C along the width of the box.
Step 6. Along these isometric construction lines, mark off the distance B, thus locating points O and P. Connect points OP.
Step 7. Connect points MO and NP to draw the non-isometric lines.

Example 3: To locating the points to obtain an isometric drawing of an irregular object
The procedure of locating the points of an irregular square pyramid is illustrated in figure 23.

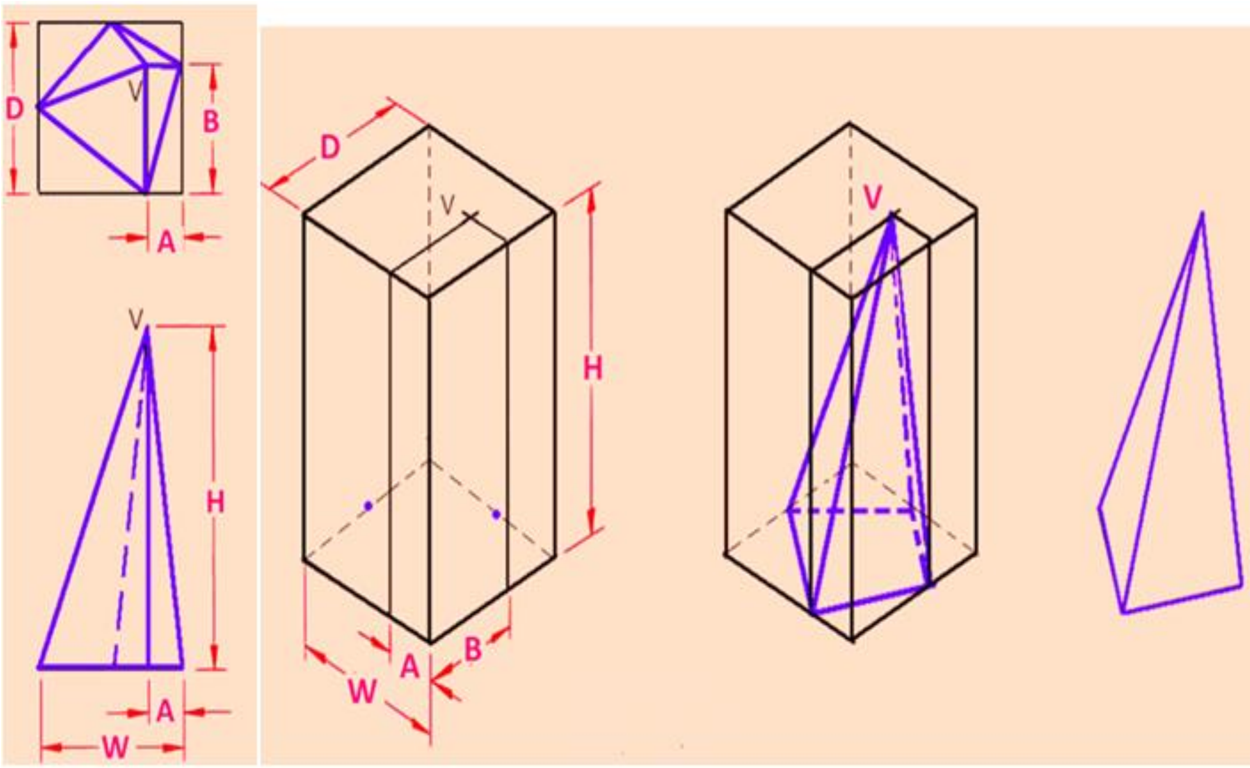


Figure 23. The method of drawing the isometric view of an irregular square pyramid

- Construct an isometric box equal to the dimensions W, H and D as measured in the multi-view drawing. Locate dimensions A and B along the base of the isometric box, then project them along the faces to the edge of the top face, using vertical lines. Project the points of intersection across the top face using isometric lines. Point V is located at the intersection of these last two projections. Locate the remaining points around the base and complete the figure.

Example 4: Draw the isometric view of the object shown in figure 24 (a)

The stepwise procedure of drawing the isometric view is shown in figure 24 (b).

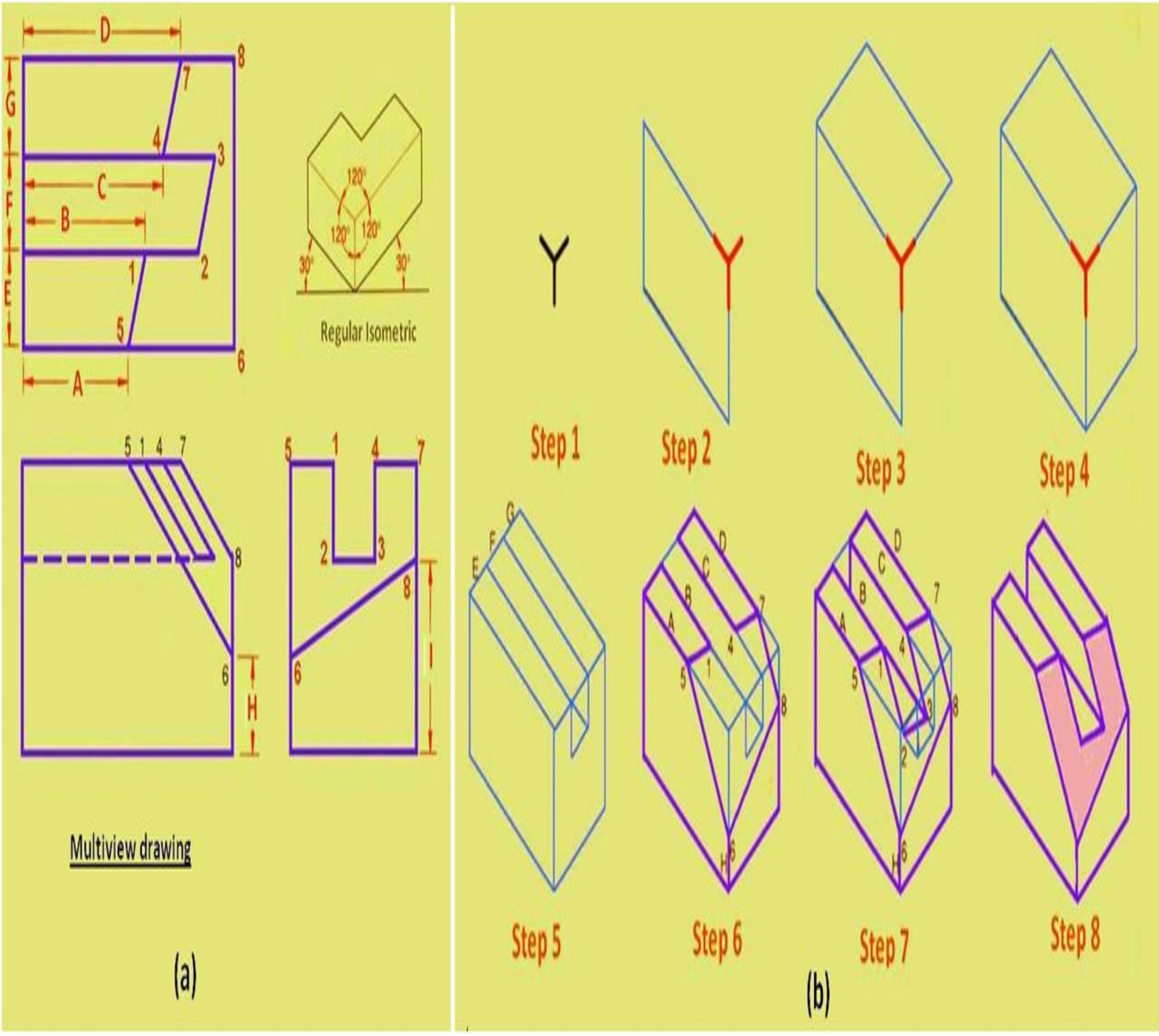


Figure 24. shows the (a) multiview drawing of an object nd (b) the stepwise procedure for drawing the isometric view.

Step 1: Determine the desired view of the object, then draw the isometric axes. The best view appeases to be that when the object is viewed from the top (regular isometric). the object will be viewed from above and the axis will be as shown in Fig. A.
Step2. Draw the isometric axes as shown in step 1.
***Step* 3.** Construct the top isometric plane using the W and D dimensions.
***Step* 4.** Construct the right side isometric plane using D and H dimensions.
***Step* 5.** Locate the slot across the top plane by measuring distances E, F, and G along isometric lines.
Step 6. Locate the endpoints of the oblique plane in the top plane by locating distances A, B, C, and D along the lines created for the slot in Step 5. Label the end-point of line A as 5, line B as 1, line C as 4, and lire D as 7. Locate distance H along the vertical isometric line in the front plane of the isometric box and label the end point 6. Then locate distance I along the isometric

line in the profile isometric plane and label the end point 8. Connect endpoints 5-7 and endpoint 6-8. Connect points 5-6 and 7-8.
***Step* 7.** Draw a line from point 4 parallel to line 7. This new line should intersect at point 3. Locate point 2 by drawing a line from point 3 parallel to line 4 and equal in length to the distance between points 1 and 4. Draw a line from point 1 parallel to line 5-6. This new line should intersect point 2.
***Step* 8.** Darken lines 4-3, 3-2, and 2-1 to complete the isometric view of the object.

- Isometric drawing of objects having irregular curved surfaces._ Irregular curves are drawn in isometric by constructing points along the curve in the multi-view drawing, locating those points in the isometric view, and then connecting the points using a drawing instrument such as a French curve.
- The multi-view drawing of the curve is divided into a number of segments by creating a grid of lines and reconstructing the grid in the isometric drawing.
- The more segments chosen, the longer the curve takes to draw, but the curve will be more accurately represented in the isometric view.

Example 5. To draw the isometric view of the object having Irregular curve shown in figure 25.

The step wise procedure of drawing isometric view of object is shown in figure 6.

***Step* 1.** On the front view of the multi-view drawing of the curve, construct parallel lines and label the points 1, 2, 3, ….., 12. Project these lines into the top view until they intersect the curve. Label these points of intersection 13, 14, 15, …18, as shown in the Figure. Draw horizontal lines through each point of intersection, to create a grid of lines.
***Step* 2.** Use the W, H, and D dimensions from the multi-view drawing to create the isometric box for the curve. Along the front face of the isometric box, transfer dimension A to locate and draw lines 1-2, 3-4, 5-6, 7-8, 9-10, and 11-12.
***Step* 3.** From points 2, 4, 6, 8, 10, and 12, draw isometric lines on the top face parallel to the D line. Measure the horizontal spacing between each of the grid lines in the top multi-view as shown for dimension B, and transfer those distances along isometric lines. parallel to the W line. The intersections of the lines will locate points 13-18.
***Step* 4.** Draw the curve through points 13-18, using an irregular curve. From points 13-18, drop vertical isometric lines equal to dimension H. From points 1, 3, 5, 7, 9, and 11 construct isometric lines across the bottom face to intersect with the vertical lines dropped from the top face to locate points 19-24. Connect points 19-24 with an irregular curve.
***Step* 5.** Erase or lighten all construction lines to complete the view

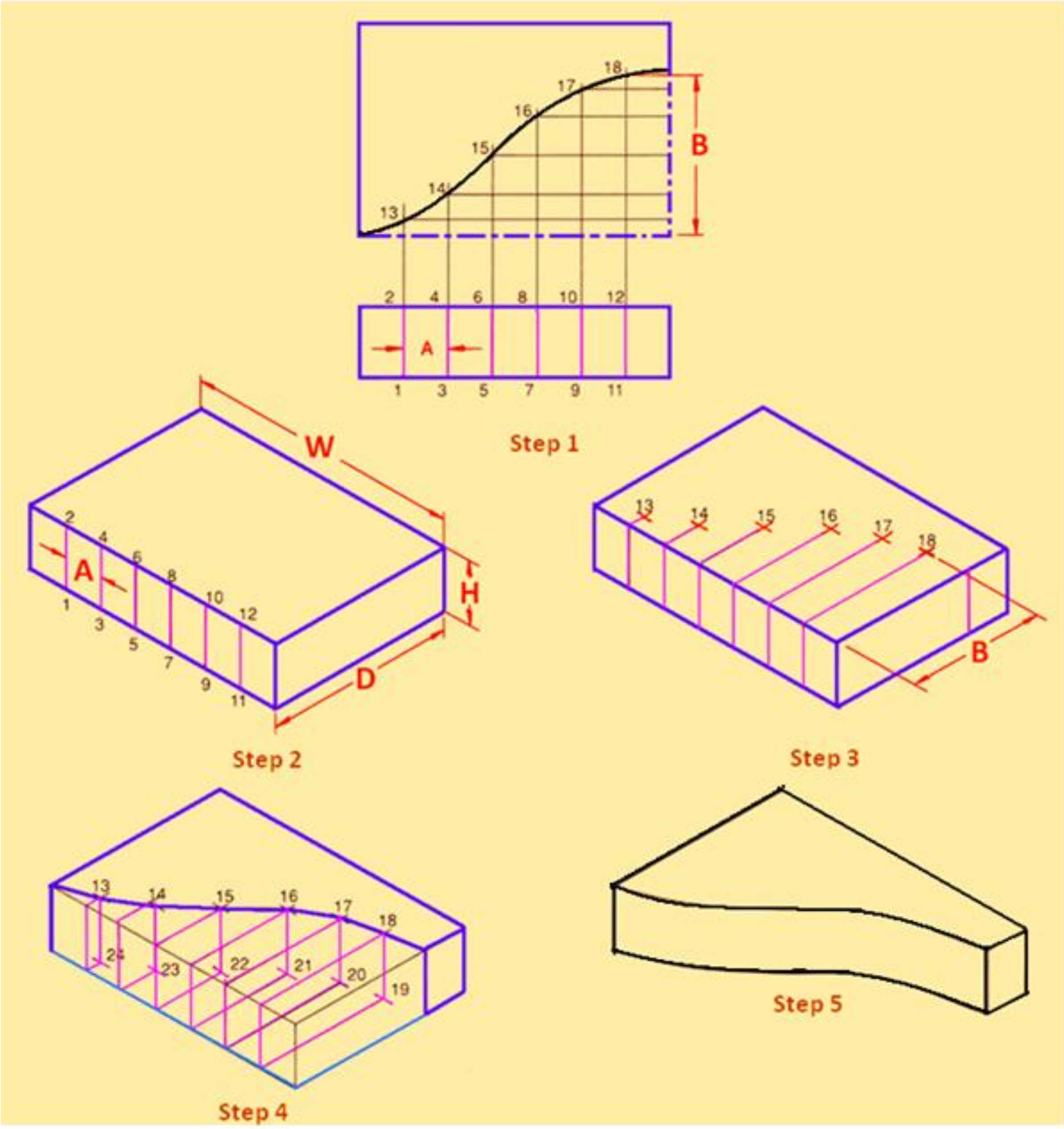


Figure 25. Isometric view of an object havingirregular curved shape.