UNIT 5 ISOMETRIC AND OBLIQUE PROJECTIONS

Structure

5.1 INTRODUCTION

Having studied the orthographic projection, we now consider isometric projection. This type of projection comes under the category of pictorial projection. Interpretation of the shape of an object from a multiview orthographic drawing requires a thorough knowledge of the principles of orthographic projections. A pictorial projection in general and an isometric projection in particular, helps the students and also the shop floor workers (from whom the knowledge of orthographic projection is not expected) to visualize clearly and fully the shape of the object. Pictorial drawings are mainly used to show complicated structures such as aircraft, rocket cell etc. Pictorial drawings in the form of exploded views are used in maintenance catalogues and manuals.

Objectives

After studying of this unit, you should be able to understand

- fundamental difference between orthographic projection and isometric projection,
- difference between isometric projection and isometric view,
- classification of pictorial drawings,

- procedures of drawing isometric and oblique projections, and
- difference between isometric projection and oblique projection.

5.2 CLASSIFICATION OF PICTORIAL DRAWINGS

The three principle forms of pictorial projections are :

- axonometric projection,
- oblique projection, and
- perspective projection.

These are also known as single-plane pictorial drawings.

Axonometric Projection

It is a three-dimensional projection of an object. This is a form of orthographic projection since the projectors are perpendicular to the plane of projection and are parallel to each other.

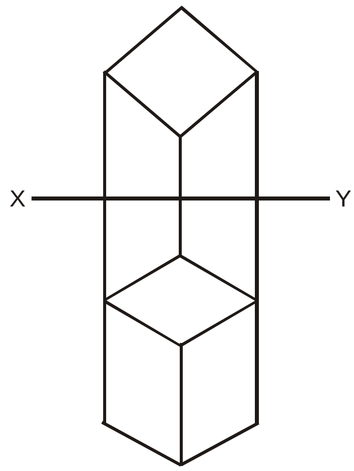


Figure 5.1

An axonometric projection is obtained by projecting an object placed in an oblique position to the picture plane.

Three types of projections are possible under this to achieve three dimensional effect. These are :

- isometric,
- diametric, and
- trimetric.

Out of these, only isometric projections are dealt with here in detail.

5.3 ISOMETRIC PROJECTION

Several orthographic views on different auxiliary planes may be required, to know fully the details of a complicated machine part.

In isometric projection, only one plane is used, i.e. plane of paper on which the drawing is made.

Isometric projection is the view obtained when the line of sight is parallel to the solid diagonal of a cube. If a cube is resting on one of its corners on the ground, with its solid diagonal perpendicular to the VP, the front view of the cube is its isometric projection.

5.3.1 Isometric Projection of a Cube

(a) Draw projections of the cube, assuring it to be resting on the ground on one of its bases and vertical faces equally inclined to the VP.

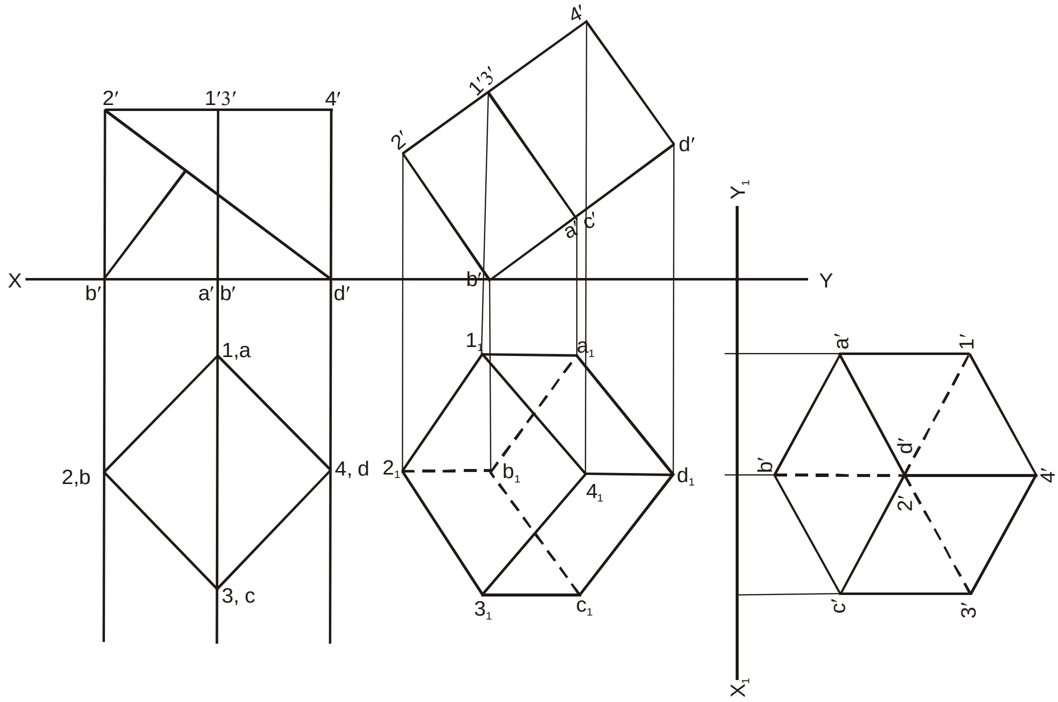


Figure 5.2

(b) Locate the solid diagonal ‘2*d*’.

(c) Redraw the front view such that the solid diagonal ‘2*d*’ is parallel to *XY*.

(d) Project the final top view.

(e) Draw X_1 Y_1 such that it is perpendicular to the solid diagonal 2_1 d_1.

(f) Project the final front view.

This final front view is also the isometric view of the cube.

5.3.2 Isometric Scale

Figure 5.3(a) shows the isometric projection of a cube with isometric axes marked. In isometric projection, the magnitudes of dimensions are reduced, therefore a special scale is required to draw the projections.

A square with *ZX* as diagonal is constructed, representing the true shape of the top surface. From the figure, it is evident that the lines *ZB* and *ZC* are inclined at 30^o and 45^o to *ZA* respectively. From the geometry,

$$\frac{ZB}{ZC} = \frac{ZB}{ZA} \cdot \frac{ZA}{ZC} = \frac{\cos 45}{\cos 30} = \frac{\sqrt{2}}{\sqrt{3}}$$

Hence $$ZB = \sqrt{\frac{2}{3}}\ ZC$$

Hence, all dimensions in the isometric projection are $\frac{\sqrt{2}}{\sqrt{3}}$ times the true size or approximately 82% of the true size.

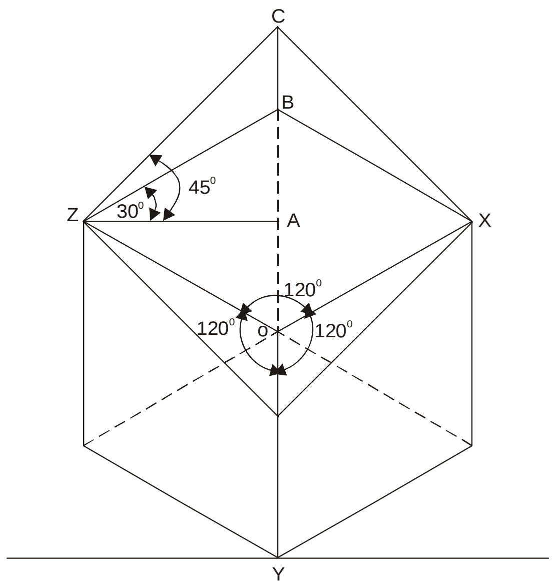


Figure 5.3(a)

To draw an isometric projection, the magnitudes of all dimensions are to be reduced to this proportion. A convenient method of reducing the dimensions is to use an isometric scale.

5.3.3 Construction of an Isometric Scale

(a) Draw a horizontal line *OA*.

(b) Draw lines *OB* and *OC* making 30° and 45° angles with *OA* respectively.

(c) Construct a regular scale to full size along the line *OC*.

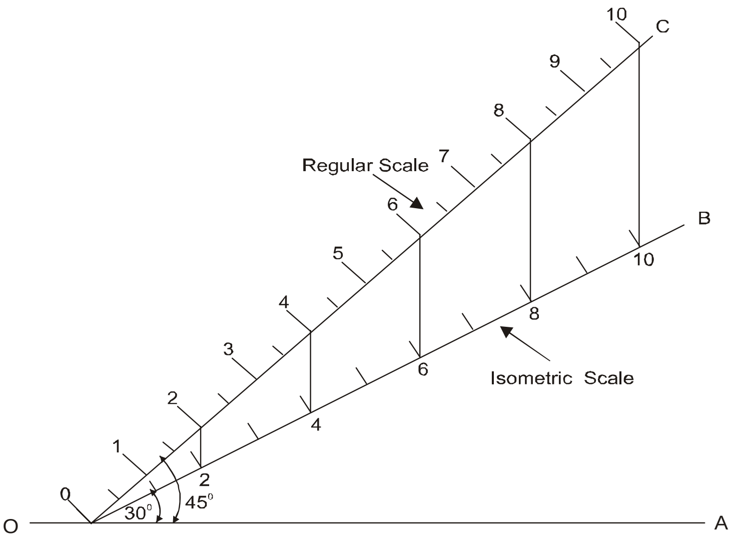


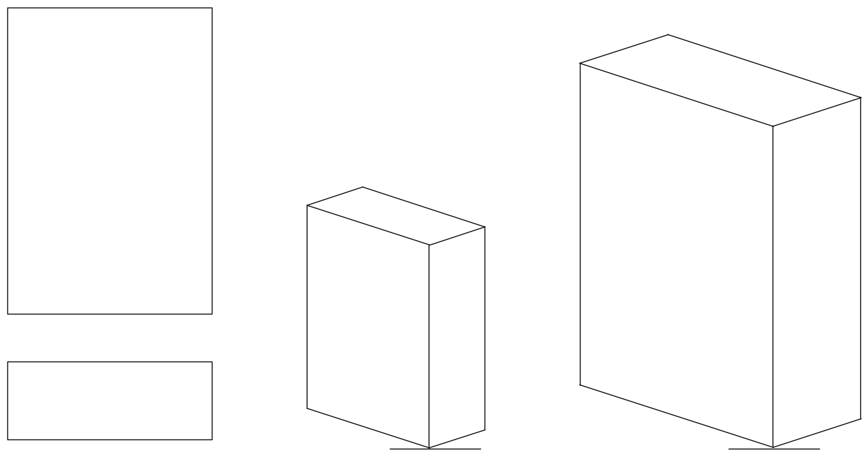
Figure 5.3(b)

(d) From the division points on the line of the regular scale, draw perpendicular to *OA* meeting *OB*.

(e) Mark the corresponding division points on the line *OB*. These points on *OB* represent the isometric distances from *O*.

It is more popular to draw isometric views (isometric drawings made to full scale, without using isometric scale), because it is easier to execute. Just for clear understanding, we can call drawings made using isometric scale as **Isometric Projection** and isometric drawings made using regular scale as **Isometric View**.

Figure 5.4 shows the isometric projection and isometric view of a rectangular prism. Compare both the figures and you will find an illusion that figure drawn with regular scale appears to be a little bigger in size. Except the size, both the drawings are alike.



(a) **(b)** **(c)**

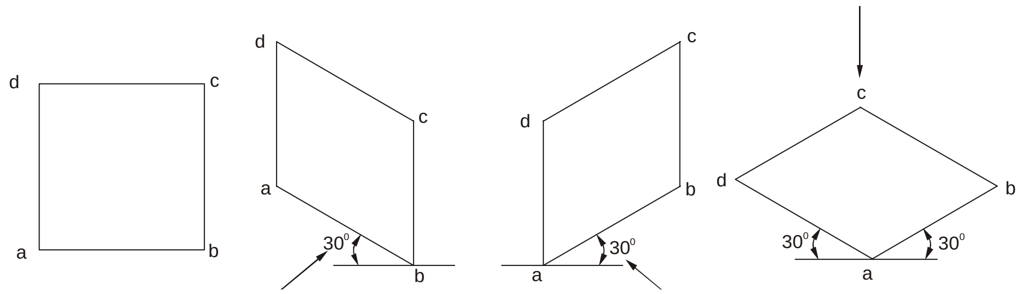
Figure 5.4

5.4 ISOMETRIC DRAWINGS OF PLANE GEOMETRICAL FIGURES

5.4.1 Isometric Drawing of a Square

Draw the square as shown in Figure 5.5(a).

The square can be projected isometrically in three different ways, as shown in Figure 5.5.



(a) **(b)** **(c)** **(d)**

Figure 5.5

(a) Draw a horizontal line and mark a point, say *b*, on the line. Draw a line *ba*, making a 30^o angle, towards the left. The length is equal to the side of the square.

(b) From point *a*, draw a vertical line *ad*, equal in length of the side of the square.

(c) From point *b*, draw a vertical line *bc*, equal in length to the side of the square.

(d) Join *d* and *c*.

bcda is the isometric drawing of the square *abcd* and it gives a feeling as if we are viewing perpendicular to the line *ba* and from the left to the right side as shown in Figure 5.5(b).

Another way in which the square could be projected is given in Figure 5.5(c). The procedure is exactly similar, but the 30^o angle is to be drawn on the right hand side. This gives a feeling as if we are looking the square in a direction perpendicular to the side *ab* and from the right to the left.

The third way is to project the square horizontally. The procedure is as follows :

(a) Draw a horizontal line and mark a point *a* on it.

(b) From point *a* draw two lines making 30^o angle with horizontal line but on opposite sides (one on left and other on right).

(c) Mark lengths on these 30^o lines, equal to the side of the square. Draw parallel lines from these points, to the opposite sides, completing the rhombus.

(d) Figure 5.5(d) represents the isometric drawing of the square when the square is considered horizontal.

5.4.2 Isometric Drawing of a Rectangle

A rectangle can be drawn isometrically in six different ways as shown in Figure 5.6. The procedure of drawing will be same as indicated in the isometric drawing of a square. The only difference will be of marking the lengths of sides corresponding to the lengths of sides of the given rectangle.

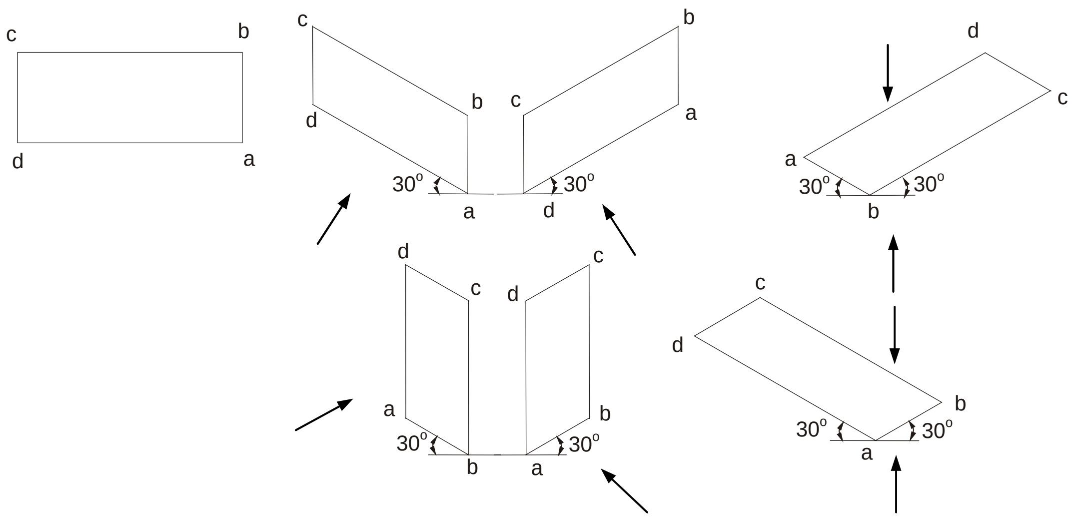


Figure 5.6 : Isometric Drawing of a Rectangle

5.4.3 Isometric Drawing of a Circle

Draw a circle and enclose it in a square *ABCD* as shown in Figure 5.7(a). Points 1, 2, 3 and 4 are the mid-points of the sides of the square *ABCD*. They lie

Figure 5.7 : Isometric Drawing of a Circle

on the isometric lines. Points 5, 6, 7 and 8 are the non-isometric points. To determine the position of a non-isometric point in an isometric drawing the procedure will be as follows

From point 5, draw line parallel to *AB* and *BC*. They will intersect *AB* and *BC* at *e* and *f*. Points *e* and *f* can be located on the sides *AB* and *BC* in isometric drawing. From these points, draw lines parallel to *AB* and *BC*. The point of intersection of these lines will be the isometric point 5. Repeat the same procedure for all other non-isometric points, i.e. 6, 7 and 8 and locate their corresponding isometric points. Draw a smooth curve (free hand), joining all these isometric points, i.e. 1, 2, 3, 4, 5, 6, 7 and 8. This closed curve will be an ellipse, and is the isometric projection of the circle.

As a square can be drawn isometrically in three different ways, so also a circle.

5.4.4 Isometric Drawing of a Triangle

Draw a triangle *ABC* and enclose it in a rectangle, *ACde* (Figure 5.8).

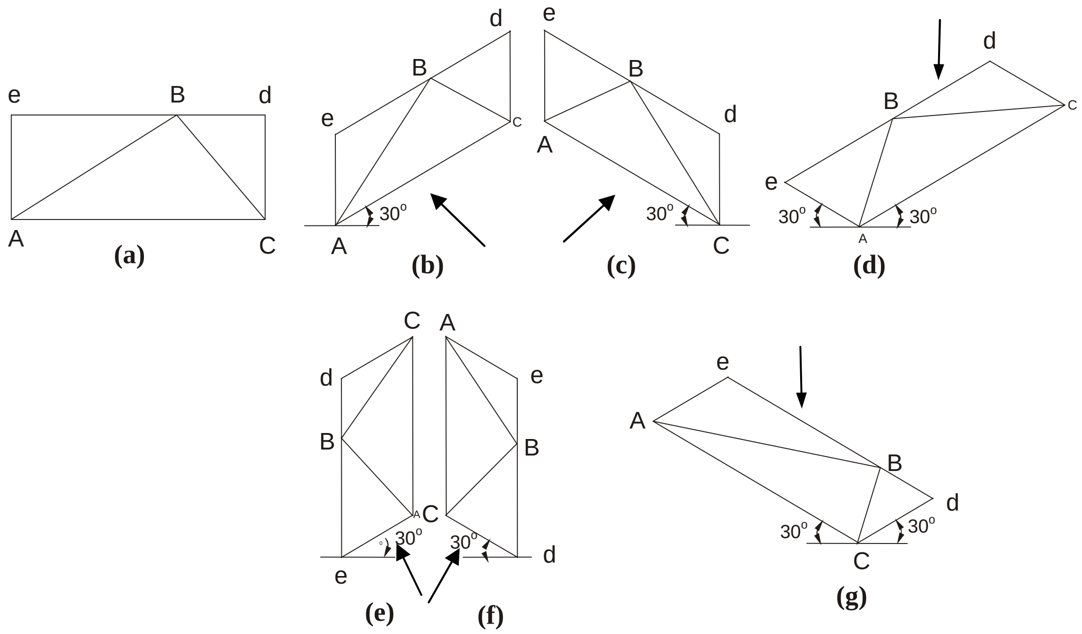


Figure 5.8

The triangle *ABC* can be isometrically projected in six different ways, as shown in Figures 5.8 (a), (b), (c), (d), (e), (f) and (g).

5.5 ISOMETRIC PROJECTION OF SOLIDS

Solids can be made by enclosing surfaces. A cube can be made by six equal squares (four vertical surfaces, one top and one bottom).

5.5.1 Procedure of Drawing a Cube

In a cube, there are two square surfaces which are horizontal, the top and the bottom.

To start an isometric drawing, we first draw the bottom square, which is horizontal *abcd* as shown in Figure 5.9.

From points *a*, *b*, *c* and *d* draw vertical lines as *ae*, *bf*, *cg*, *dh* equal in length to the sides of the square. Join *e*, *f*, *g* and *h*. The figure represents the isometric view of a cube. The edges, which are not visible, are drawn with dotted lines in this explanatory drawing. In general, the hidden edges, which are not visible in an isometric drawing, are not drawn.

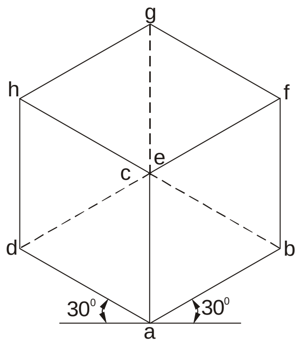


Figure 5.9

5.5.2 Isometric Drawing of Simple Machine Brackets

If orthographic views of an object are given and it is desired to draw an isometric drawing of the same object, the first and foremost requirement is to have perfect knowledge of orthographic reading and correct interpretation. By reading orthographic views and co-relating them, one must be able to imagine the shape of the object whose orthographic drawing is given. Once this is achieved, drawing the isometric view becomes easier.

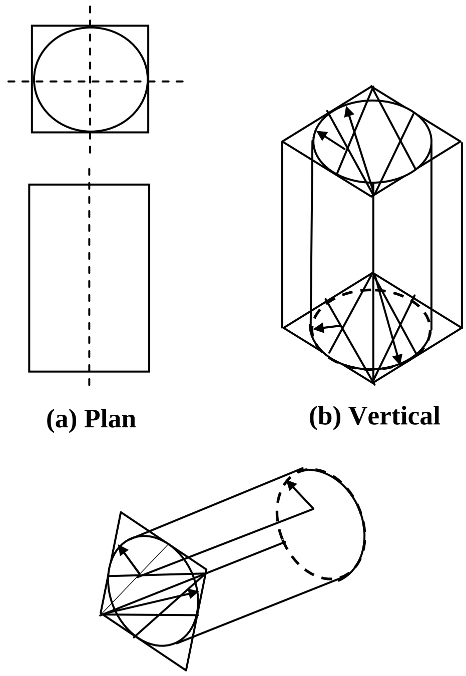
The popular method of drawing the isometric view from the given orthographic views is the Box-Method. The orthographic views are enclosed in appropriate shapes (usually rectangles or squares) and then a box of the same size is drawn isometrically. In the second stage, the surfaces touching the sides of the box are marked on the box and, thus, the object is fully drawn. The box is then erased off.

Example 5.1

Draw the isometric view of a right cylinder assuming its axis (i) Vertical (ii) Horizontal.

Solution

Draw Plan and Elevation of the right cylinder as shown in Figure 5.10(a).



(a) Plan

(b) Vertical

(c) Horizontal Axis

Figure 5.10

The orthographic views are drawn in third angle method of projection. (These may be drawn in first angle as well.) The top view is a circle and the front view is a rectangle.

The circle is enclosed in a square. Now the entire cylinder may be considered as enclosed in a square prism.

The isometric view of the square prism is drawn. Draw two ellipses on the two horizontally drawn squares. These ellipses may be drawn as free hand smooth curves after locating the isometric points (as explained earlier) or may be drawn using compass with four centre method. Here, it is drawn with four centre method.

Ellipse drawn with four centre method will differ in shape from the ellipse drawn with free hand (free hand drawn curve is more correct) but to avoid the combursome method of free hand curve, four centre method is more popular.

After drawing the two ellipses, draw two tangential lines to them. Thus, the isometric drawing of the cylinder is completed.

The second part of the problem can be drawn, considering the axis to be horizontal. The two squares surfaces (ends of the cylinder) will become vertical. The ellipses are drawn as shown in the Figure. The cylinder is completed after drawing the tangents to these ellipses.

SAQ 1

(a) Draw orthographic views (plan and elevation) of a right and regular triangular pyramid having its base on the ground and the base is so placed that (i) its top view is enclosed in a square having two sides perpendicular to *X*-*Y*, and (ii) one corner of the base is considering with the right hand side top corner of the enclosing square.

After drawing the orthographic views, draw an isometric view of the pyramid (assume suitable dimensions).

(b) The two orthographic views of a machine part are given in third angle projection method in Figure 5.11. Draw its isometric view.

Figure 5.11

5.6 OBLIQUE PROJECTION

An oblique projection is produced by parallel projectors that make some angle other than 90^o with the plane of projection. In doing so, an oblique projection is not an orthographic view. Rather it is a contrived view without orthogonal basis.

In normal axonometric projection, the projectors are perpendicular to the plane of projection and the principal faces of the object are oblique to it. In oblique projection, the projectors are oblique to the plane of projection but parallel to each other, while one principal face of the object is placed parallel to it.

Oblique projection differs from the isometric projection. In this, two axes are always perpendicular to each other while the third, known as receding axis, is at some convenient angle such as 30^o, 45^o or 60^o with horizontal as shown in Figure 5.12.

Figure 5.12

Oblique projection is more flexible and also has advantages like

(a) irregular outlines on the front face appear in their true shape,

(b) distortion can be reduced by foreshortening the receding axis, and

(c) choice is permitted in the selection of the position of the axes to obtain the realistic appearance as shown in Figure 5.13.

Figure 5.13

As the human eye is accustom to seeing the objects with receding lines appearing to converge, an oblique projection presents an unusual appearance. This appearance of distortion may be decreased by lessening the length of the receding lines. If the receding lines are measured to the true size, the projection is known as "*cavalier*" projection. If the receding lines are reduced to one half of their true length, the projection is called the "*cabinet*" projection. This type of oblique drawing is used in furniture industries.

5.6.1 Rules for Placing an Object

Generally, the most irregular face, or the one with the most circular outlines, should be drawn true shape as the front face. By following this practice, all or most of the circles and arcs can be drawn with a compass. The tedious construction that would be required to complete their elliptical representations on receding planes is eliminated.

The second rule is that choose the longest face to be the front face. When the longest face of an object is used as the front face, the pictorial view will appear less distorted. If these two rules clash, the first should govern. It is more desirable to have an irregular face show in true shape than to lessen the distortion in the direction of the receding axis.

5.6.2 Procedure for Constructing an Oblique Drawing

(a) Draw the three axes that form the perpendicular edges through a point representing the front corner (Figure 5.14(b)). Point *O* has been used for this purpose.

(b) Set off width and height to construct the front face in true size and shape. This is identical to the orthographic front view (Figure 5.14 (c)).

Figure 5.14

(c) Draw depth lines parallel to the receding axis from corners and centres of the front face (Figure 5.14(d)). Use depth distances from the orthographic top view (Figure 5.14(a)), to determine the position of the back face.

(d) The centre of the hole and radius arc is found in the same manner. Note that a small portion of the 12.5 radius arc is needed to complete Figure 5.14(e).

(e) The circle and semicircle are shown parallel to the picture plane to avoid distortion and to make their construction as easy as possible.

SAQ 2

(a) Figure 5.15 shows the two orthographic views of a machine bracket. Draw these views and also an oblique view on 45^{o} receding axis.

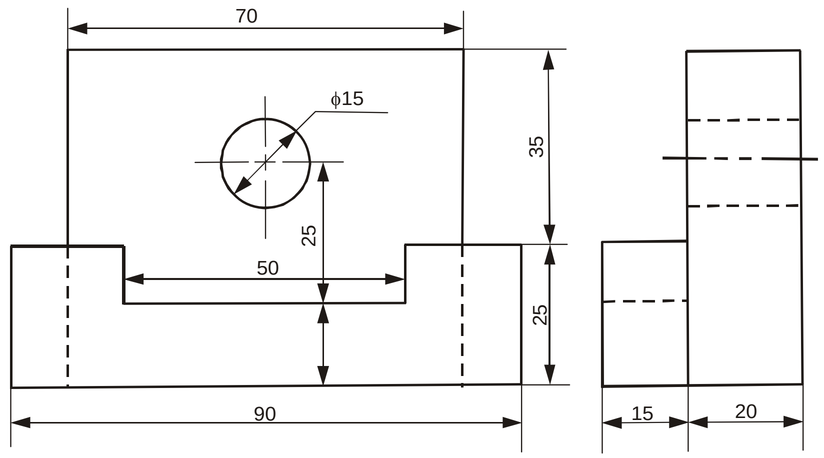


Figure 5.15

(b) Figure 5.16 shows the orthographic views of a machine bracket. Draw an oblique view.

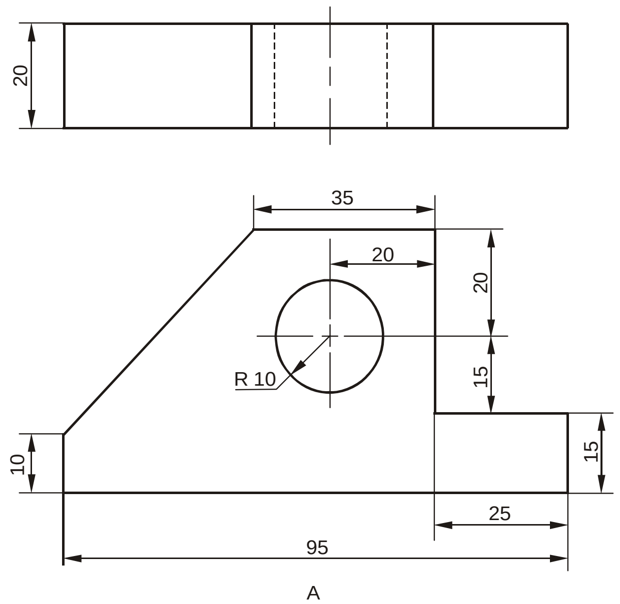


Figure 5.16

(c) Figure 5.17 shows the orthographic views of a machine bracket. Draw its oblique view.

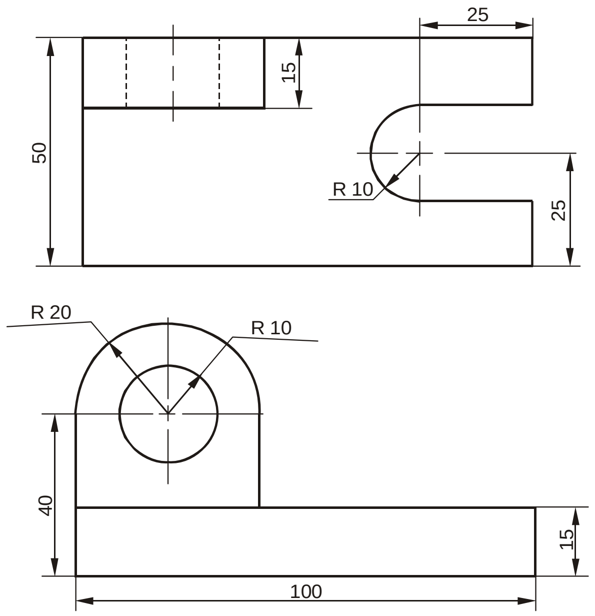


Figure 5.17

5.7 ILLUSTRATIVE EXAMPLES

Example 5.2

Figure 5.18 shows the isometric view of machine bracket. Draw its orthographic view.

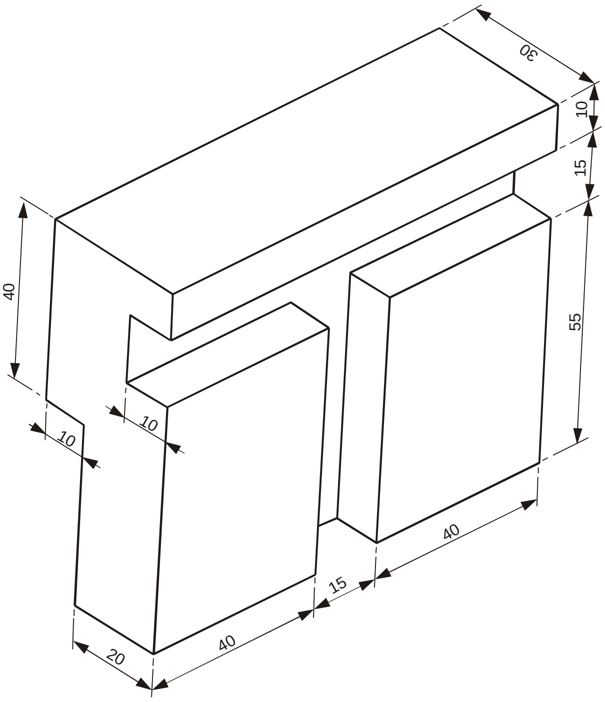


Figure 5.18

Solution

Orthographic view of the machine bracket is shown in Figure 5.19.

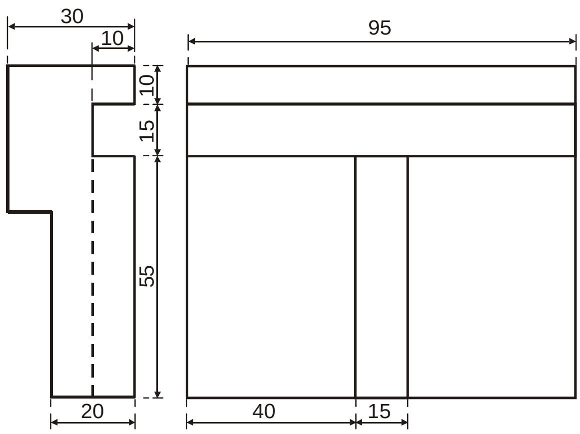


Figure 5.19

Example 5.3

Figures 5.20, 5.21 and 5.22 show orthographic views of machine brackets. Draw these views and also the isometric projections of the brackets.

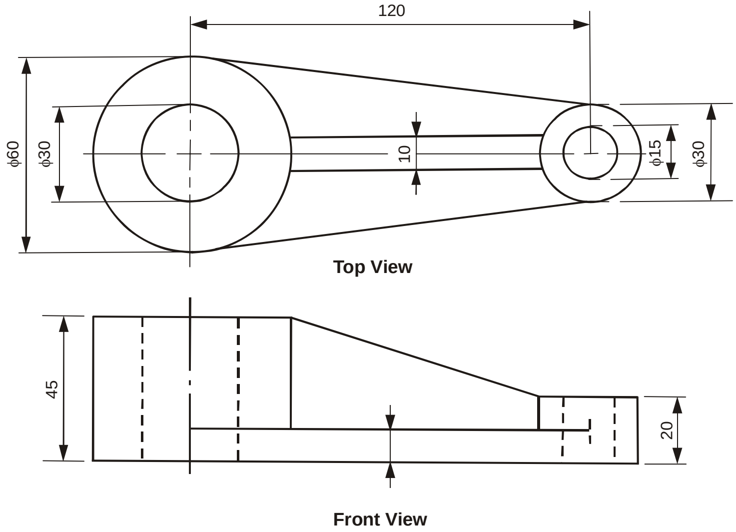


Figure 5.20

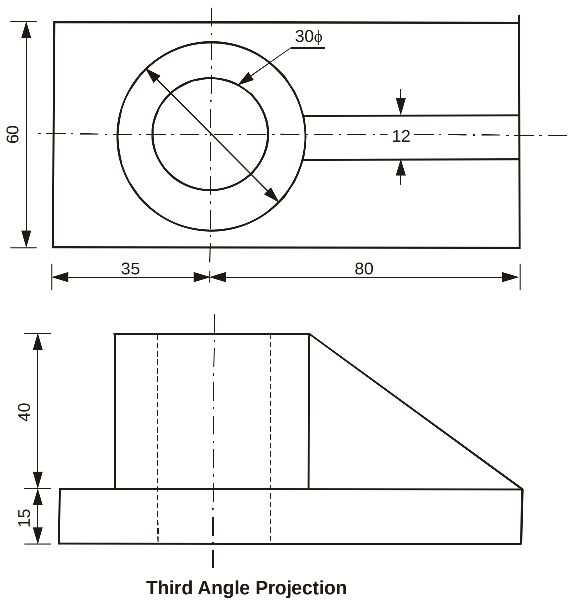


Figure 5.21

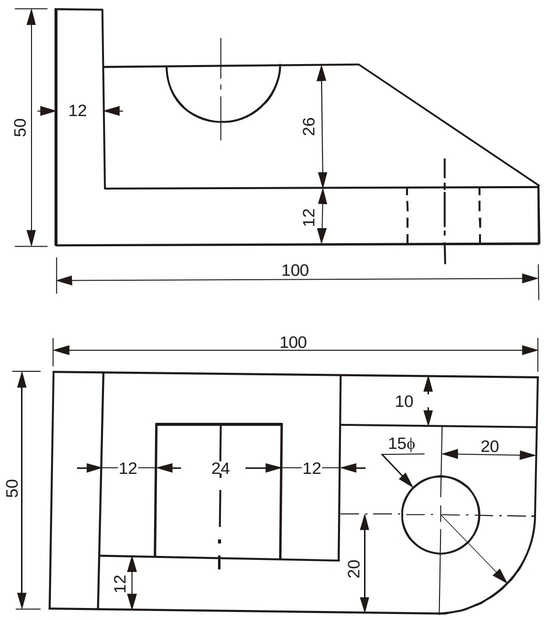


Figure 5.22

Solution

Isometric projection of the machine brackets are shown in Figures 5.23, 5.24 and 5.25 respectively.

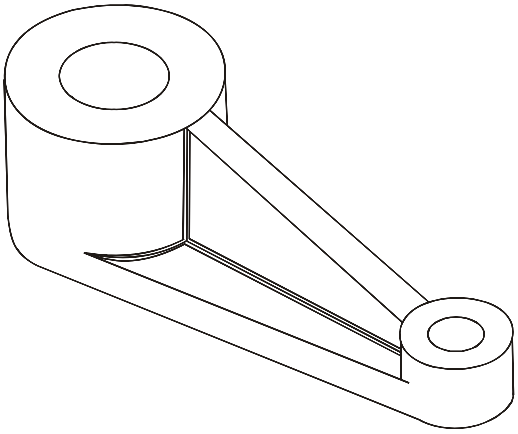


Figure 5.23

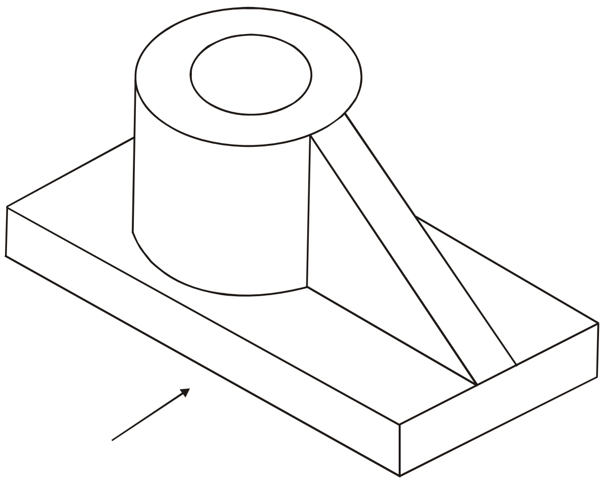


Figure 5.24

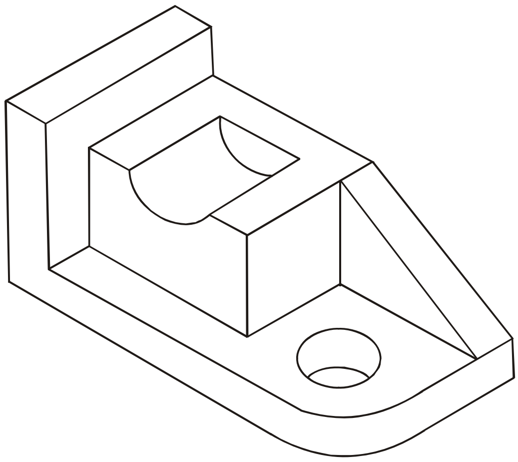


Figure 5.25

Example 5.4

Figures 5.26, 5.27 and 5.28 show the orthographic views of machine brackets. Draw their oblique views at a convenient angle of the receding axis.

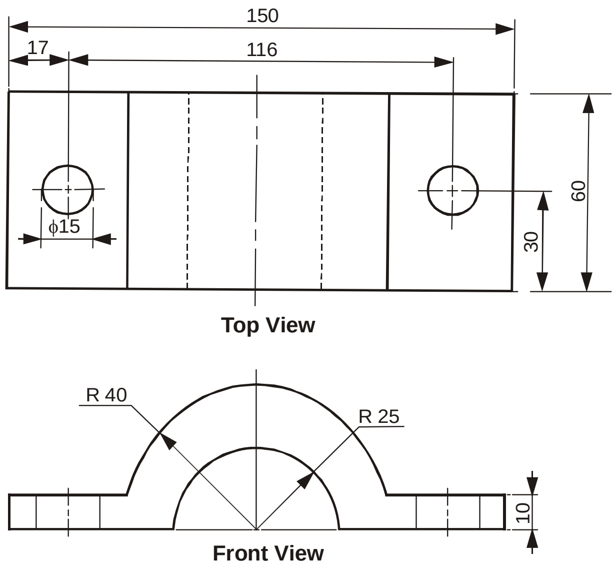


Figure 5.26

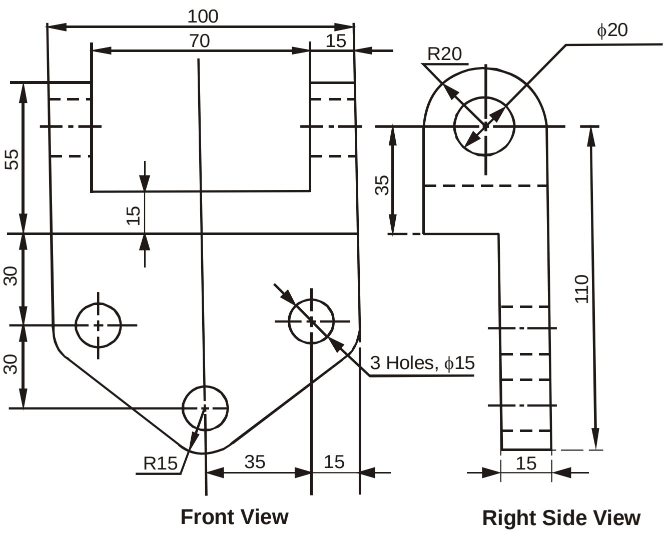


Figure 5.27

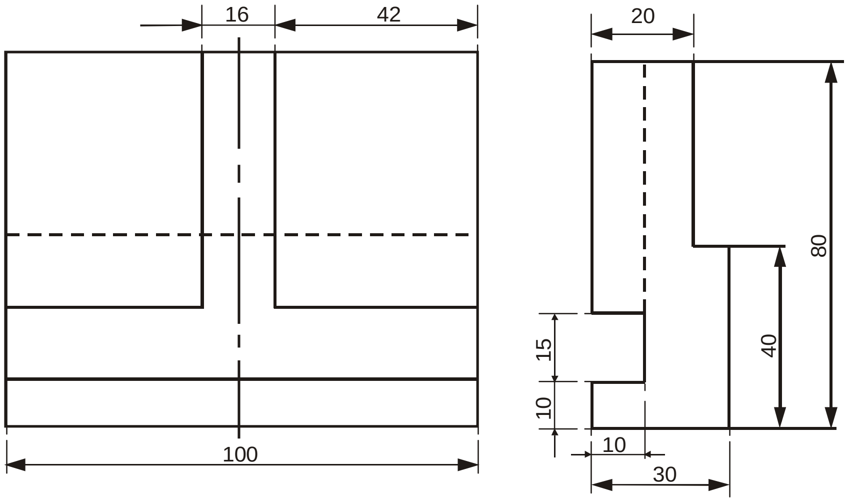


Figure 5.28

Solution

Oblique views of the machine brackets are shown in Figures 5.29, 5.30 and 5.31 respectively.

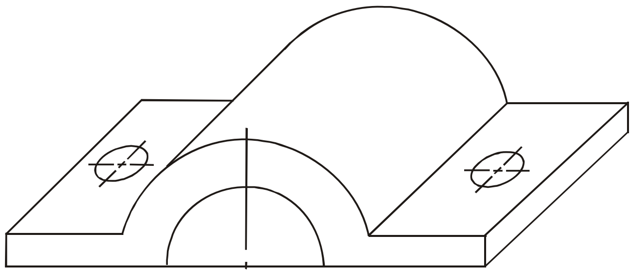


Figure 5.29

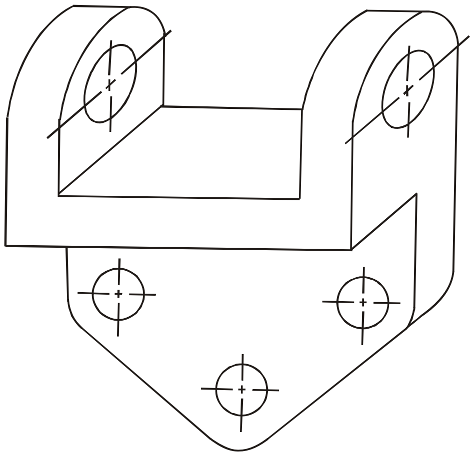


Figure 5.30

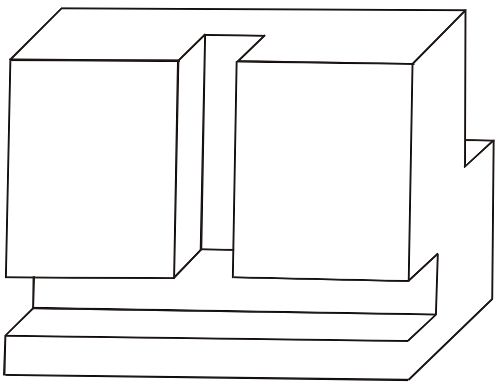


Figure 5.31

5.8 SUMMARY

Isometric drawing of an object is pictorial projections which can be interpreted easily even by a person having inadequate knowledge of the orthographic drawings. For making a three-dimensional isometric drawing the knowledge of drawing plane surfaces in the isometric views is a must. Simple geometric figures like square, rectangle, triangle, circle etc. must be learnt to draw isometrically. Joining these figures, solids can be constructed isometrically.

Use of isometric scale makes the final isometric projections, which are more alike the real object. Isometric drawings made to true scale look bigger in size.

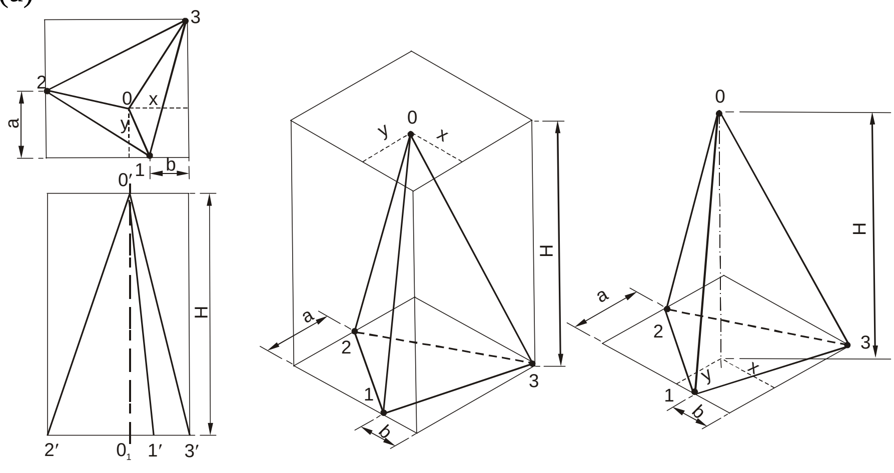
The other method of drawing pictorial views is an “oblique projection”. In this method, the front view of an object is same as an orthographic view but the depth is drawn on receding line inclined at a convenient angle (30^o, 45^o or 60^o).

It requires a trick in selecting the front view of the given object, i.e. how to keep an object for drawing an oblique projection. The view which has more circular holes, curves and complicated details must be chosen as front view, so that drawing all these details in the receding lines in distorted shapes is avoided. A little practice will teach how to select the front view to draw an easy oblique projection.

5.9 ANSWERS TO SAQs

SAQ 1

(a)



(a) **(b) Box Method** **(c) Off-set Method**

Figure 5.32

(b)

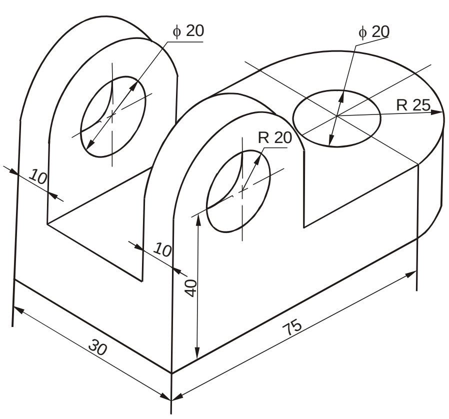


Figure 5.33

SAQ 2

(a)

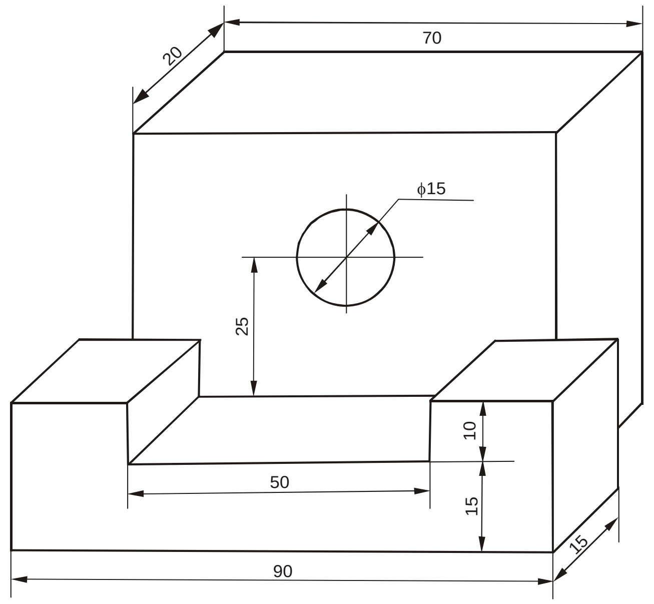


Figure 5.34

(b)

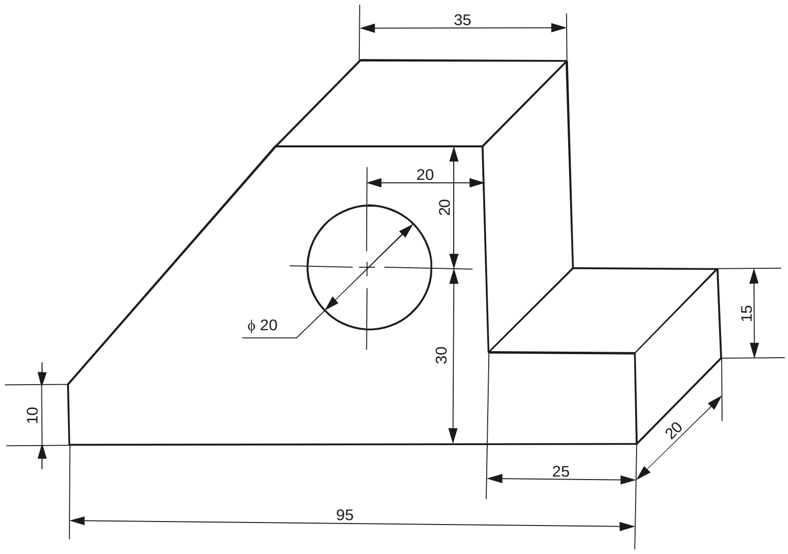


Figure 5.35

(c)

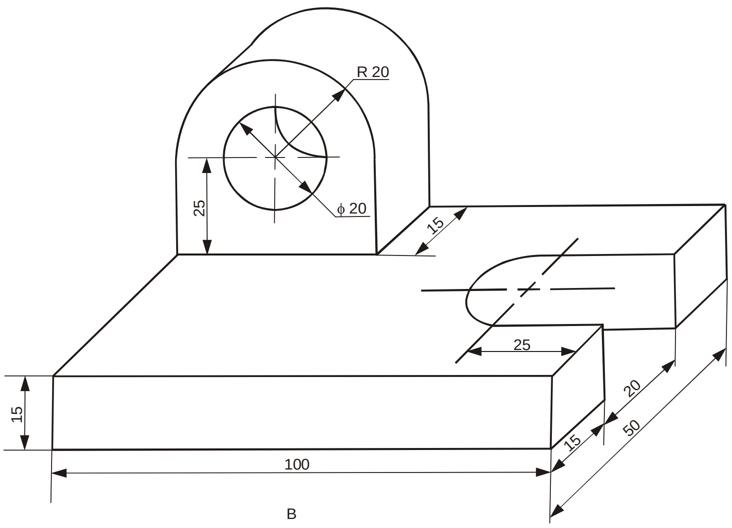


Figure 5.36