INTRODUCTION

Drawing is the Graphical means of expression of technical details without the barrier of a language. Engineering Drawing is the Universal Language for Engineers.

Drawing is a graphic representation of:

- a real thing,
- an idea or,
- a proposed design for later manufacture or construction.

Graphic representation:

- Artistic: to express aesthetic, philosophic or other abstract ideas
- Technical: to represent the design of objects to be built or constructed

Dimensioning

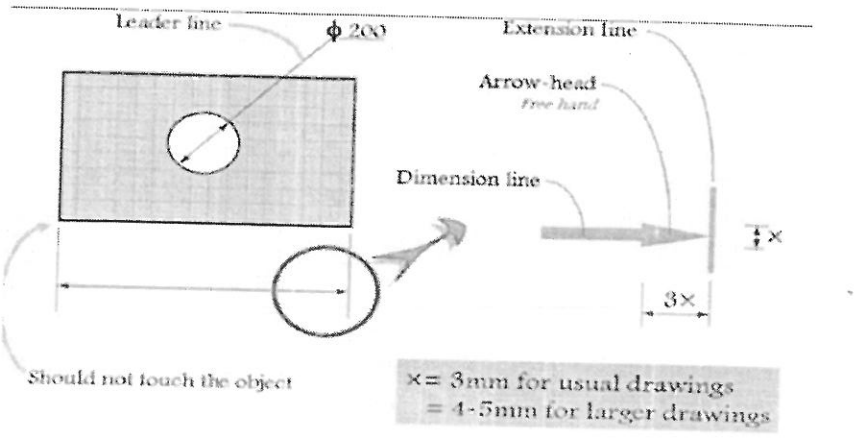
BIS (SP 46: 2003) defines dimension as a numerical value expressed in appropriate units of measurement and indicated graphically on technical drawings with lines, symbols and notes.

The important aspects of dimensioning are as follows:

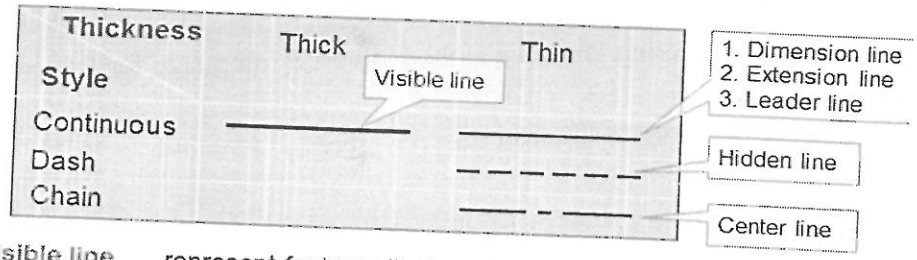
Units of Measurement the most convenient unit for length is millimetre. Angles are shown in degrees. Symbols are incorporated to indicate specific geometry wherever necessary.

(a). Types of Lines& Applications:

Lines are one important aspect of technical drawing. Lines are always used to construct meaningful drawings. Various types of lines are used to construct drawing, each line used in some specific sense.



Basic Line Types &Application



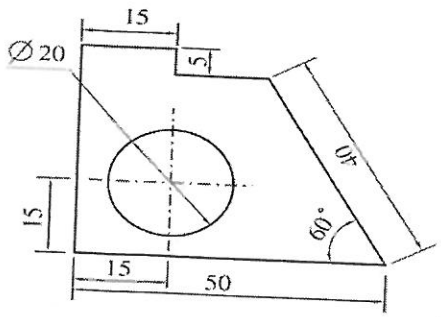
1. **Visible line** represent features that can be seen in the current view.
2. **Dimension line**
   Extension line
   Leader line indicate the sizes and location of features.
3. **Hidden line** represent features that can not be seen in the current view.
4. **Center line** represents symmetry, path of motion, centers of circles, axis of axisymmetrical parts

- Dimension lines should be drawn at least 10 mm away from the outlines.
- Smaller dimensions should be placed nearer the view and the larger further away so that extension lines do not cross dimension lines.
- As far as possible, all the dimensions should be placed outside the views. Inside dimensions are preferred only if they are clearer and more easily readable.

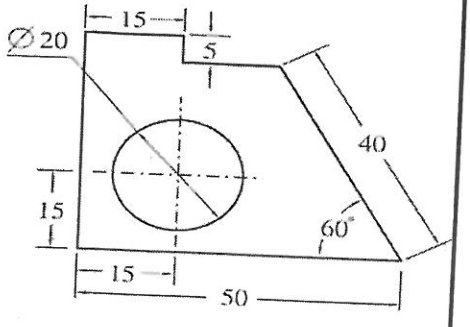
(b). Placing Of Dimensions:

All the dimensions on a drawing must be shown using either Aligned System or Unidirectional System. Two systems be mixed on the same drawing.

Aligned System: Dimensions are placed perpendicular to the dimension line so that they may be read from the bottom or right-hand side of the drawing sheet. Dimensions are placed at the middle and above of the dimension lines.



Unidirectional System: Dimensions are placed in such away that they can be read from the bottom edge of the drawing sheet. Dimension lines are broken near the middle for inserting the dimensions.



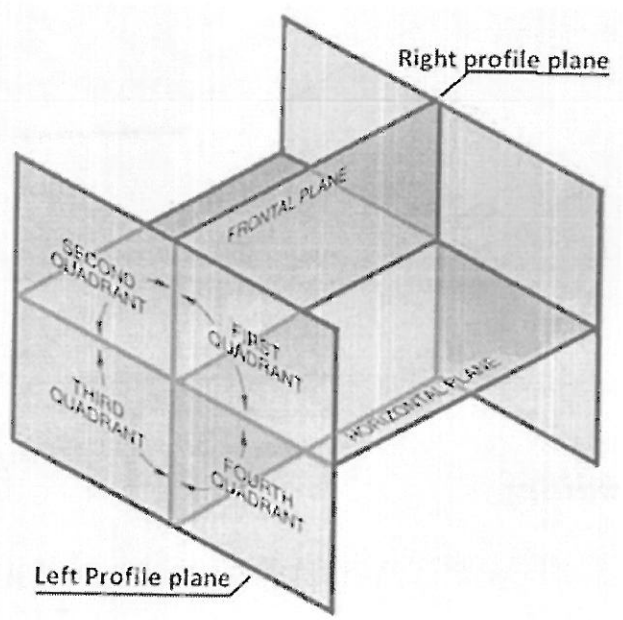
UNIT-2

PROJECTION OF POINTS

In engineering, 3-dimensonal objects and structures are represented graphically on a 2-dimensional media. The act of obtaining the image of an object is termed "projection". The image obtained by projection is known as a "view".

POINT:

The position of a point in engineering drawing is defined with respect to its distance from the three principle planes i.e., with respect to the VP, HP, & PP.

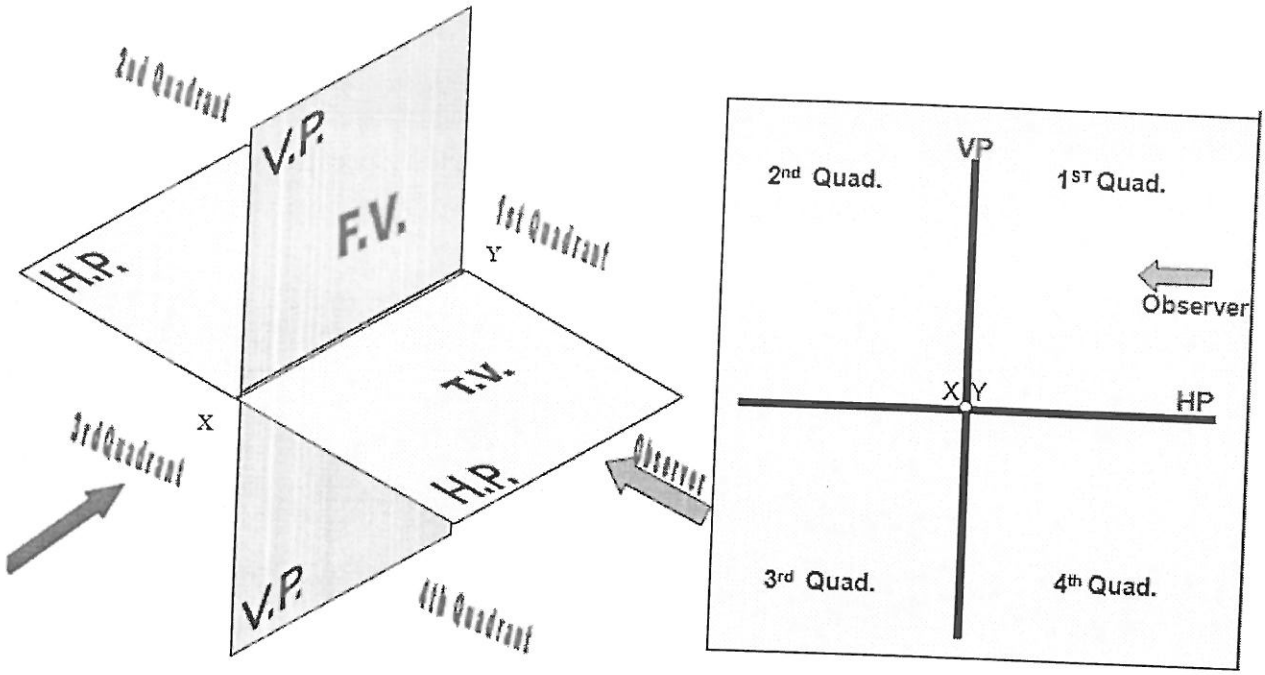


Conventions used while drawing the projections of points

With respect to the 1st angle projection of point 'P',

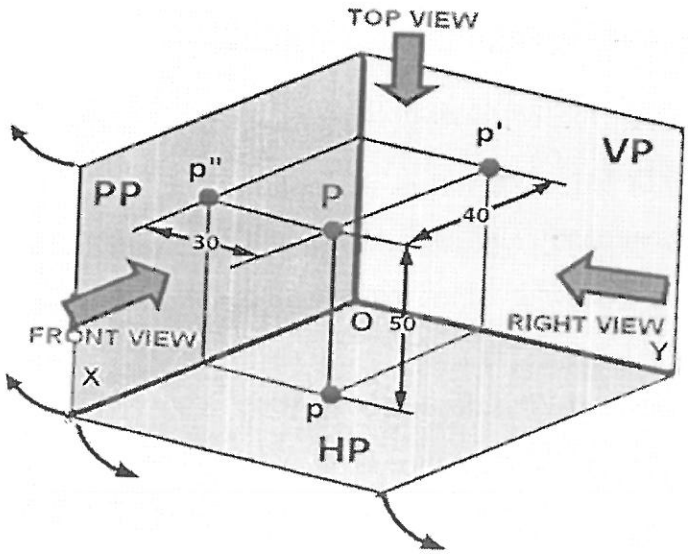
- Top views are represented by only small letters. **example: p**
- Their front views are conventionally represented by small letters with dashes. **example: P′**
- Profile or side views are represented by small letters with double dashes. **example: p″**
- Projectors are shown as thin lines.
- The line of intersection of HP and VP is denoted as X-Y.
- The line of intersection of VP and PP is denoted as X1-Y1

This quadrant pattern, If observed along X-Y Line (in red arrow direction) will exactly appear as shown on right side and hence, It is further used to understand illustration properly.



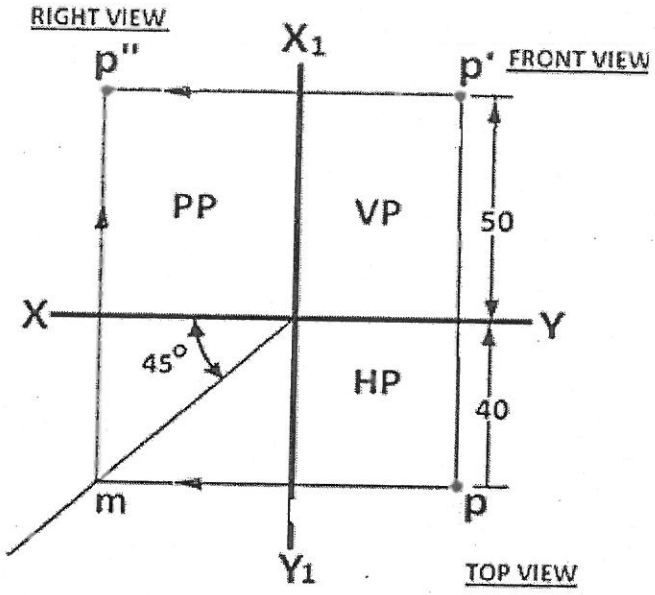
Point in the First quadrant

Figure shown the projections of a point P which is 40 mm in front of VP, 50 mm above HP,



The procedure of drawing the three views of the point "P" is shown in above figure.

- Draw a thin horizontal line, XY, to represent the line of intersection of HP and VP.
- Draw X_1Y_1 line to represent the line of intersection of VP and AVP (PP).
- Draw the projector line
- Draw the Front View (p′).
- Draw the Top View (p).
- To project the side view on the AVP, draw a horizontal projector through P to intersect the 45 degree line at M. Through M draw a vertical projector to intersect the horizontal projector drawn through p′ at p′′.
- p′′ is the side view of point P



9-1. A POINT IS SITUATED IN THE FIRST QUADRANT

The pictorial view [fig. 9-1(i)] shows a point *A* situated above the H.P. and in front of the V.P., i.e. in the first quadrant. *a'* is its front view and *a* the top view. After rotation of the plane, these projections will be seen as shown in fig. 9-1(ii).

The front view *a'* is above *xy* and the top view *a* below it. The line joining *a'* and *a* (which also is called a projector), intersects *xy* at right angles at a point *o*. It is quite evident from the pictorial view that *a'o* = *Aa*, i.e. the distance of the front view from *xy* = the distance of *A* from the H.P. viz. *h*. Similarly, *ao* = *Aa'*, i.e. the distance of the top view from *xy* = the distance of *A* from the V.P. viz. *d*.

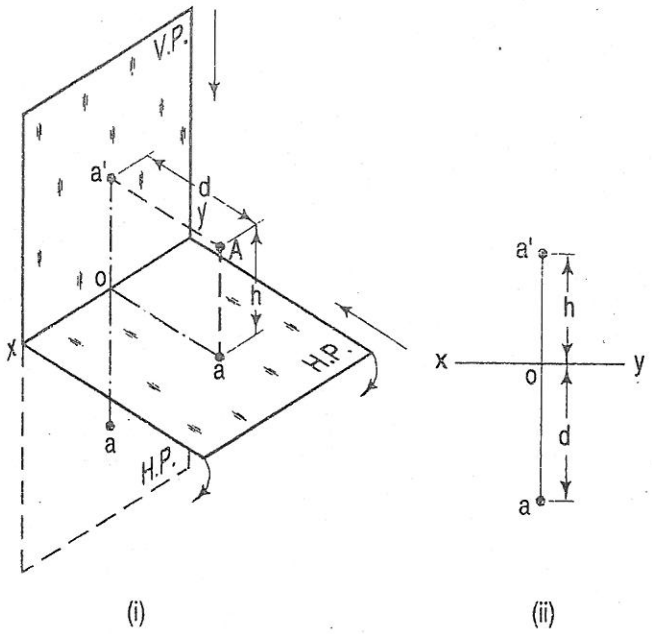
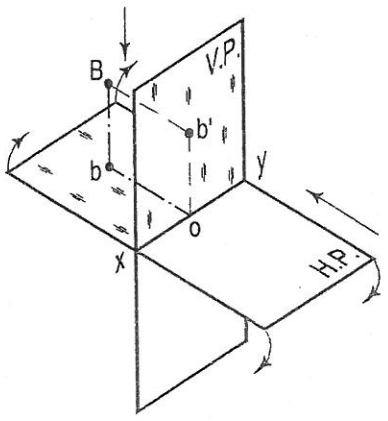


FIG. 9-1

9-2. A POINT IS SITUATED IN THE SECOND QUADRANT

A point *B* (fig. 9-2) is above the H.P. and behind the V.P., i.e. in the second quadrant. *b'* is the front view and *b* the top view.

When the planes are rotated, both the views are seen above *xy*. Note that *b'o* = *Bb* and *bo* = *Bb'*.



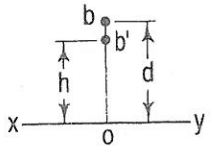


FIG. 9-2

9-3. A POINT IS SITUATED IN THE THIRD QUADRANT

A point *C* (fig. 9-3) is below the H.P. and behind the V.P., i.e. in the third quadrant. Its front view c' is below *xy* and the top view *c* above *xy*. Also *c'o* = *Cc* and *co* = *Cc'*.

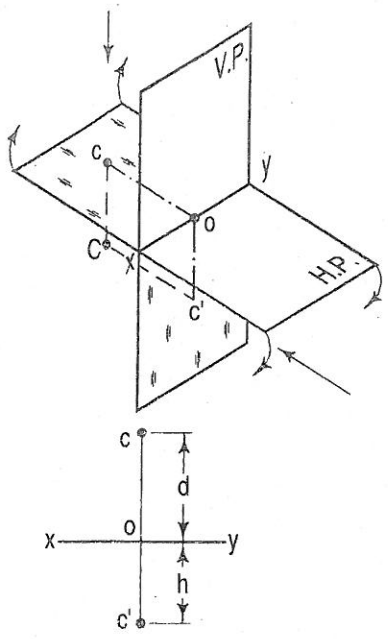


FIG. 9-3

9-4. A POINT IS SITUATED IN THE FOURTH QUADRANT

A point *E* (fig. 9-4) is below the H.P. and in front of the V.P., i.e. in the fourth quadrant. Both its projections are below *xy*, and *e'o* = *Ee* and *eo* = *Ee'*.

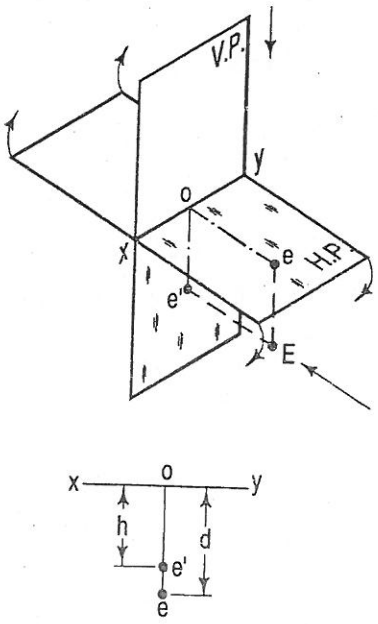


FIG. 9-4

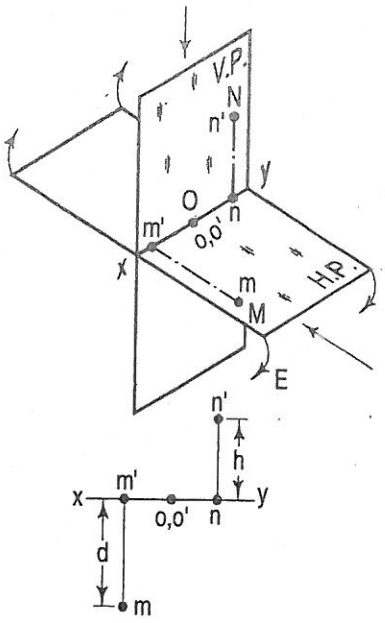


FIG. 9-5

Referring to fig. 9-5, we see that,

(i) A point *M* is in the H.P. and in front of the V.P. Its front view *m'* is in *xy* and the top view *m* below it.

(ii) A point *N* is in the V.P. and above the H.P. Its top view *n* is in *xy* and the front view *n'* above it.

(iii) A point *O* is in both the H.P. and the V.P. Its projection *o* and *o'* coincide with each other in *xy*.

9-5. GENERAL CONCLUSIONS

(i) The line joining the top view and the front view of a point is always perpendicular to *xy*. It is called a *projector*.

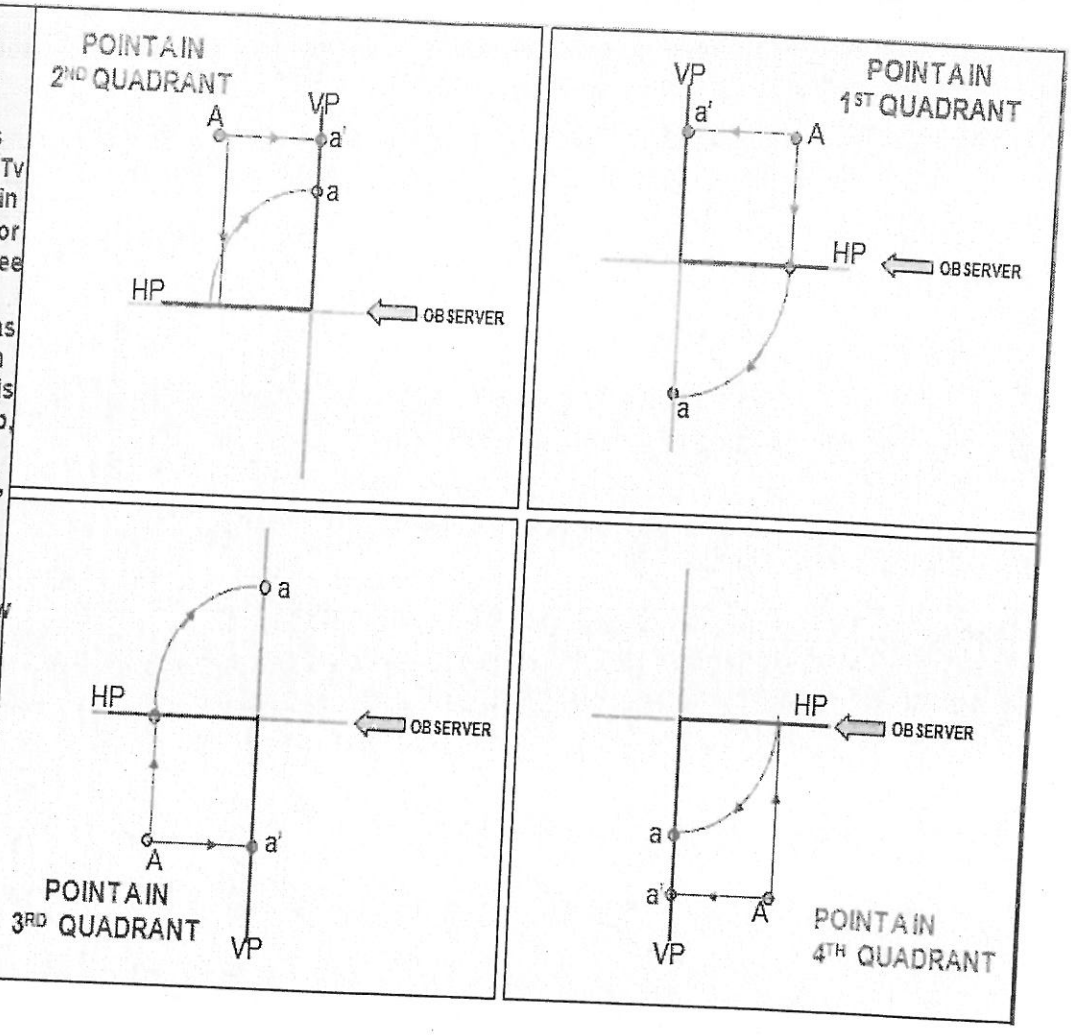
(ii) When a point is above the H.P., its front view is above *xy*; when it is below the H.P., the front view is below *xy*. The distance of a point from the H.P. is shown by the length of the projector from its front view to *xy*, e.g. *a'o*, *b'o* etc.

(iii) When a point is in front of the V.P., its top view is below *xy*; when it is behind the V.P., the top view is above *xy*. The distance of a point from the V.P. is shown by the length of the projector from its top view to *xy*, e.g. *ao*, *bo* etc.

PROJECTIONS OF A POINT SITUATED IN FOUR QUADRANTS

Point A is Placed in different quadrants and it's Fv & Tv are brought in same plane for Observer to see clearly.
Fv is visible as it is a view on VP. But as Tv is is a view on Hp, it is rotated downward 90°, In clockwise direction. The In front part of Hp comes below xy line and the part behind Vp comes above.

Observe and note the process.



Difference between first- and third-angle projections:

First angle projection	Third-angle projection
Object is kept in the first quadrant.	Object is assumed to be kept in the third quadrant.
Object lies between observer and the plane of projection.	Plane of projection lies between the observer and the object.
The plane of projection is assumed to be non-transparent.	The plane of projection is assumed to be transparent.
Front (elevation) view is drawn above the XY line	Front (elevation) view is drawn below the XY line
Top (plan) view is drawn below the XY line	Top (plan) view is drawn above the XY line
Left view is projected on the right plane and vice versa	Left view is projected on the left plane itself.
Followed in India, European countries	Followed in USA

Problem 9-1. (fig. 9-1): *A point A is 25 mm above the H.P. and 30 mm in front of the V.P. Draw its projections.*

(i) Draw the reference line *xy* [fig. 9-1(ii)].

(ii) Through any point *o* in it, draw a perpendicular.

As the point is above the H.P. and in front of the V.P. its front view will be above *xy* and the top view below *xy*.

(iii) On the perpendicular, mark a point *a'* above *xy*, such that *a'o* = 25 mm. Similarly, mark a point *a* below *xy*, so that *ao* = 30 mm. *a'* and *a* are the required projections.

Problem 9-2. (fig. 9-6): *A point A is 20 mm below the H.P. and 30 mm behind the V.P. Draw its projections.*

As the point is below the H.P. and behind the V.P., its front view will be below *xy* and the top view above *xy*.

Draw the projections as explained in problem 9-1 and as shown in fig. 9-6.

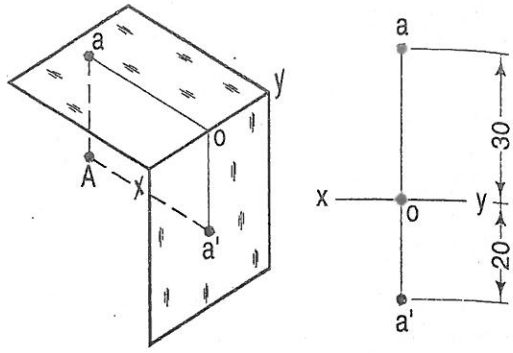


FIG. 9-6

Projections on auxiliary plane: Sometime projections of object on the principal (H.P. and V.P.) are insufficient. In such situation, another projection plane perpendicular to the principal planes is taken. This plane is known as auxiliary plane. The projection on the auxiliary plane is known as side view or side elevation. Refer fig. 9-8.

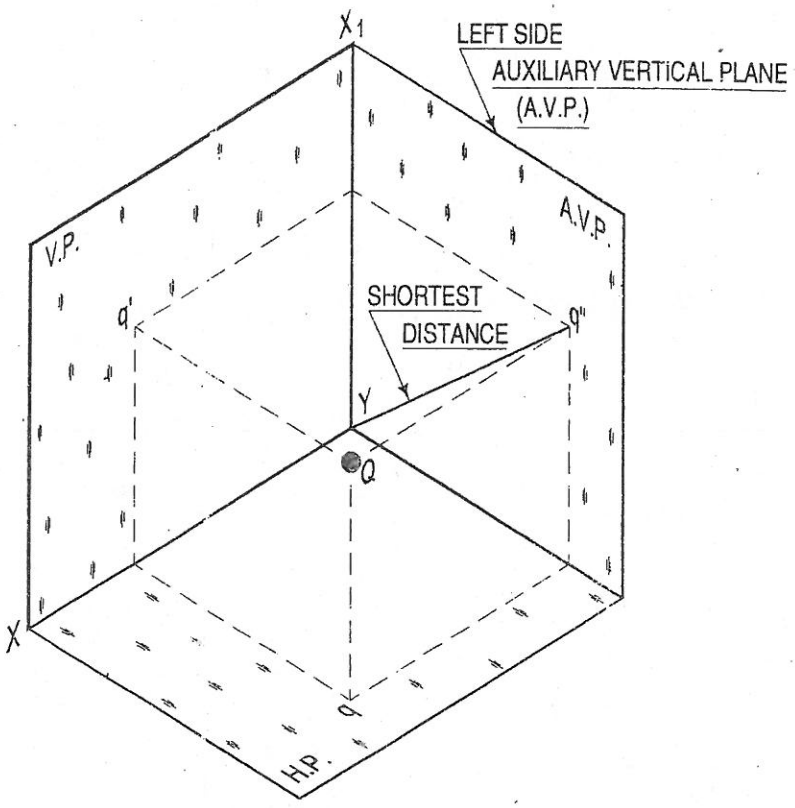


FIG. 9-8

Problem 9-3. (fig. 9-7): *A point P is in the first quadrant. Its shortest distance from the intersection point of H.P., V.P. and Auxiliary vertical plane, perpendicular to the H.P. and V.P. is 70 mm and it is equidistant from principal planes (H.P. and V.P.). Draw the projections of the point and determine its distance from the H.P. and V.P.*

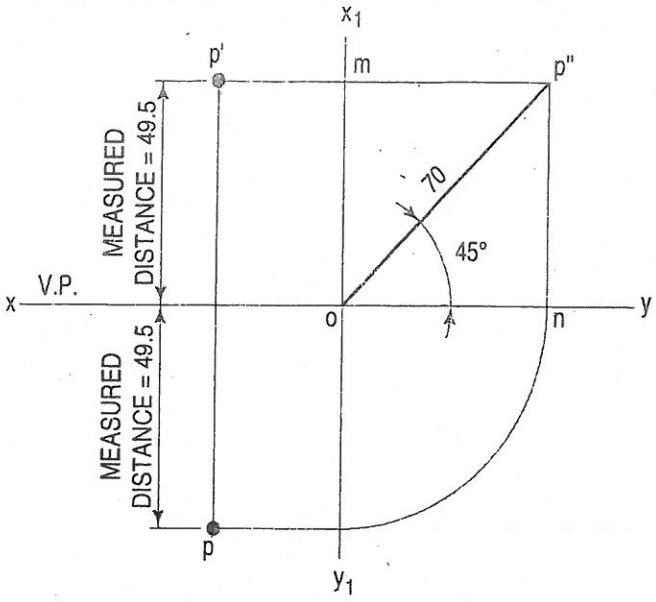


FIG. 9-7

Note: O represents intersection of H.P., V.P. and A.V.P.

(i) Draw xy and $x_1\ y_1$ perpendicular reference lines.

(ii) O represents intersection of H.P., V.P. and A.V.P.

(iii) Draw from O a line inclined at 45° of 70 mm length.

(iv) Project from P'' on xy line and $x_1\ y_1$. The projections are n and m respectively as shown in figure. From O draw arc intersecting $x_1\ y_1$.

(v) Draw a parallel line at convinent distance from $x_1\ y_1$. Extend $P''m$ to intersect a parallel line at p' and p as shown.

(vi) Measure distance from xy line, which is nearly 49.4974 mm say 49.5 mm.

EXERCISES 9

1. Draw the projections of the following points on the same ground line, keeping the projectors 25 mm apart.

   A, in the H.P. and 20 mm behind the V.P.

   B, 40 mm above the H.P. and 25 mm in front of the V.P.

   C, in the V.P. and 40 mm above the H.P.

   D, 25 mm below the H.P. and 25 mm behind the V.P.

   E, 15 mm above the H.P. and 50 mm behind the V.P.

   F, 40 mm below the H.P. and 25 mm in front of the V.P.

   G, in both the H.P. and the V.P.

2. A point *P* is 50 mm from both the reference planes. Draw its projections in all possible positions.

3. State the quadrants in which the following points are situated:

   (a) A point *P*; its top view is 40 mm above *xy*; the front view, 20 mm below the top view.

   (b) A point *Q*, its projections coincide with each other 40 mm below *xy*.

4. A point P is 15 mm above the H.P. and 20 mm in front of the V.P. Another point Q is 25 mm behind the V.P. and 40 mm below the H.P. Draw projections of P and Q keeping the distance between their projectors equal to 90 mm. Draw straight lines joining (i) their top views and (ii) their front views.

5. Projections of various points are given in fig. 9-9. State the position of each point with respect to the planes of projection, giving the distances in centimetres.

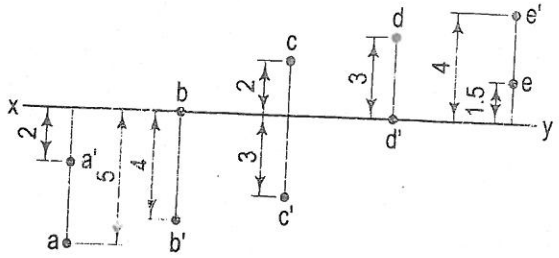


FIG. 9-9

6. Two points A and B are in the H.P. The point A is 30 mm in front of the V.P., while B is behind the V.P. The distance between their projectors is 75 mm and the line joining their top views makes an angle of 45° with xy. Find the distance of the point B from the V.P.

7. A point P is 20 mm below H.P. and lies in the third quadrant. Its shortest distance from xy is 40 mm. Draw its projections.

8. A point A is situated in the first quadrant. Its shortest distance from the intersection point of H.P., V.P and auxiliary plane is 60 mm and it is equidistant from the principal planes. Draw the projections of the point and determine its distance from the principal planes.

9. A point 30 mm above xy line is the plan-view (top view) of two points P and Q. The elevation of P is 45 mm above the H.P. while that of the point Q is 35 mm below the H.P. Draw the projections of the points and state their position with reference to the principal planes and the quadrant in which they lie.

10. A point Q is situated in first quadrant. It is 40 mm above H.P. and 30 mm in front of V.P. Draw its projections and find its shortest distance from the intersection of H.P., V.P. and auxiliary plane.

PROJECTION OF STRAIGHT LINES

Straight line

A line is a geometric primitive that has length and direction, but no thickness. Straight line is the Locus of a point, which moves linearly. Straight line is also the shortest distance between any two given points.

The location of a line in projection quadrants is described by specifying the distances of its end points from the VP, HP and PP. A line may be:

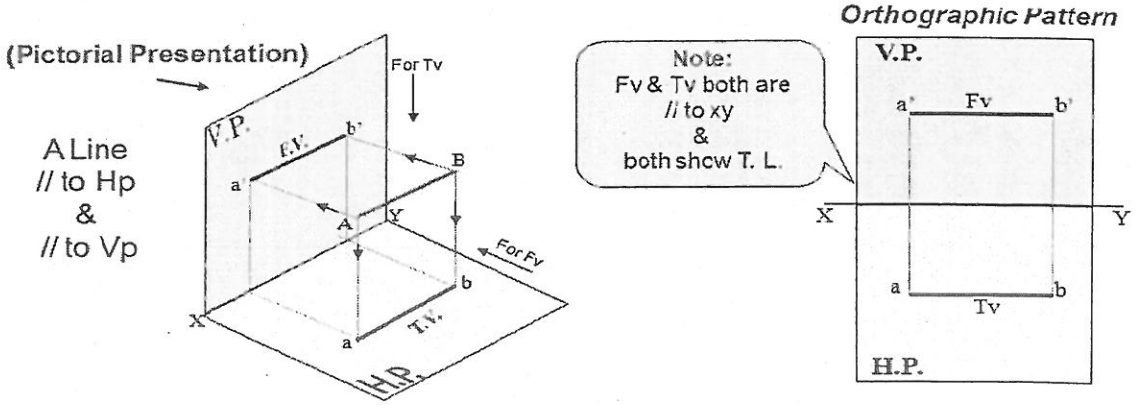
- Parallel to both the planes.
- Parallel to one plane and perpendicular to the other.
- Parallel to one plane and inclined to the other.
- Inclined to both the planes.

Projection of a line

The projection of a line can be obtained by projecting its end points on planes of projections and then connecting the points of projections. The projected length and inclination of a line, can be different compared to its true length and inclination.

Case 1: Projection of a line parallel to both HP and VP

A line AB is parallel to both HP and VP. To draw the projection of line AB, assume the line in the first quadrant. The projection points of AB on the vertical plane VP, horizontal plane HP and since the line is parallel to both HP and VP, both the front view a'b' and the top view ab are in true lengths. After projection on to the projection planes, the planes are rotated such that all the projection planes lie in the same planes.

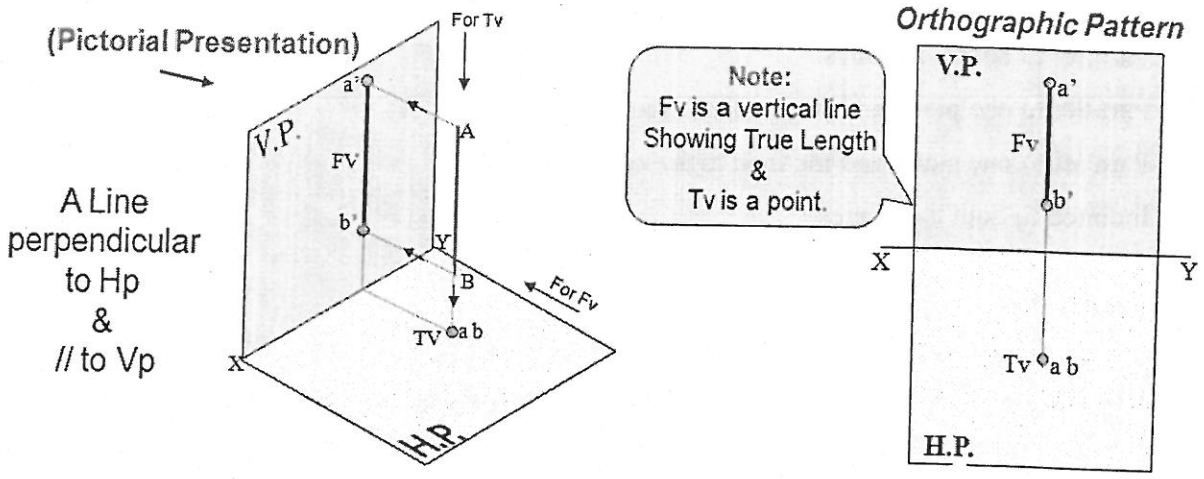


Case 2: Projection of a line parallel to one plane and perpendicular to the other.

(a) Line perpendicular to HP & parallel to VP

A line AB is parallel to VP and perpendicular to HP. The projections of line AB shown in figure and it can be obtained by the following method.

Draw a line XY which is the intersection between VP and HP. Draw the front view a'b' perpendicular to the XY line, with the lower end b' lying above the XY line. Project the top view of the line which will be a point a(b) below the XY line.



(b) Line perpendicular to VP & parallel to HP

A line CD is parallel to HP and perpendicular to VP. The projections of line CD shown in figure and it can be obtained by the following method.

Draw a line XY which is the intersection between VP and HP. Draw the front view c'd' above XY line. Project the top view of the line cd perpendicular to XY line.

Hence, when a line is perpendicular to a plane its projection on that plane is a point; while its projection on the other plane is a line equal to its true length and perpendicular to the reference line

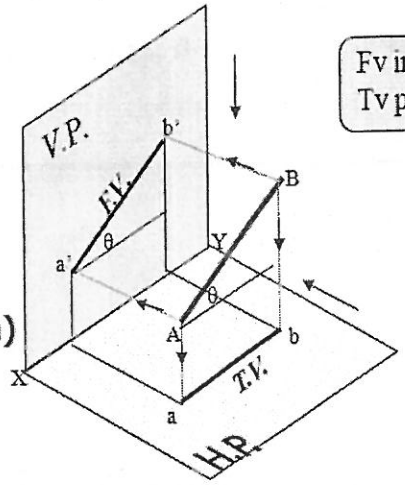
Case 3: Projection of a line inclined to one plane and parallel to the other.

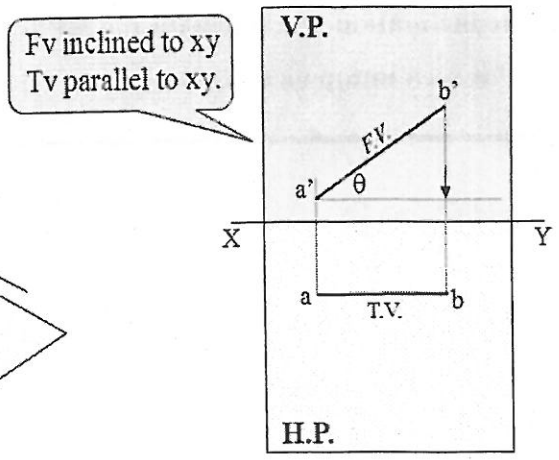
(a) Projection of a line inclined to HP and parallel to VP

A line AB, inclined to HP and parallel to VP. The projections of line AB shown in figure can be obtained in the following manner.

Draw a line XY which is the intersection between VP and HP. Draw the front view a'b' inclined to the XY line at an angle θ. Project the top view of the line which will be a line ab parallel to the XY line.

A Line inclined to Hp
and
parallel to Vp
(Pictorial presentation)



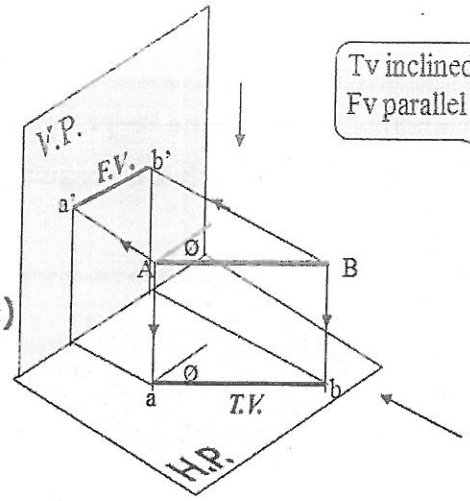


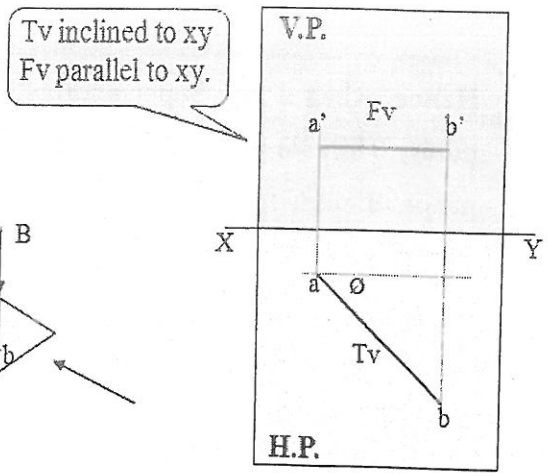
(b) Projection of a line inclined to VP and parallel to HP

A line AB, inclined to VP and parallel to HP. The projections of line AB shown in figure can be obtained in the following manner.

Draw a line XY which is the intersection between VP and HP. Draw the front view a'b' parallel to the XY line. Project the top view of the line which will be a line ab inclined at an angle φ with XY line.

A Line inclined to Vp
and
parallel to Hp
(Pictorial presentation)





Hence, when a line is inclined to one plane and parallel to the other, its projection on the plane to which it is inclined, is a line shorter than its true length but parallel to the reference line. Its projection on the plane to which it is parallel, is a line equal to its length and inclined to the reference line at its true inclination.

The inclination of a line with the HP is seen in the front view (VP) and that with the VP is seen in top view (HP).

Examples :-

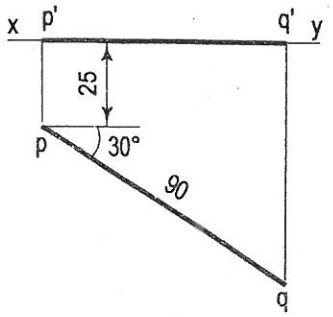


FIG. 10-6

Problem 10-1. (fig. 10-6): *A line PQ, 90 mm long, is in the H.P. and makes an angle of 30° with the V.P. Its end P is 25 mm in front of the V.P. Draw its projections.*

As the line is in the H.P., its top view will show the true length and the true inclination with the V.P. Its front view will be in *xy*.

(i) Mark a point *p*, the top view 25 mm below *xy*. Draw a line *pq* equal to 90 mm and inclined at 30° to *xy*.

(ii) Project *p* to *p'* and *q* to *q'* on *xy*.

pq and *p'q'* are the required top view and front view respectively.

Problem 10-2. (fig. 10-7): *The length of the top view of a line parallel to the V.P. and inclined at 45° to the H.P. is 50 mm. One end of the line is 12 mm above the H.P. and 25 mm in front of the V.P. Draw the projections of the line and determine its true length.*

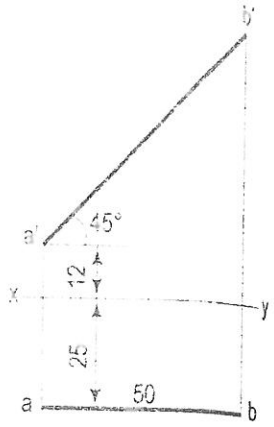


Fig. 10-7

As the line is parallel to the V.P., its top view will be parallel to *xy* and the front view will show its true length and the true inclination with the H.P.

(i) Mark *a*, the top view, 25 mm below *xy* and *a'*, the front view, 12 mm above *xy*.

(ii) Draw the top view *ab* 50 mm long and parallel to *xy* and draw a projector through *b*.

(iii) From *a'* draw a line making 45° angle with *xy* and cutting the projector through *b* at *b'*. Then *a'b'* is the front view and also the true length of the line.

Problem 10-3. (fig. 10-8): *The front view of a 75 mm long line measures 55 mm. The line is parallel to the H.P. and one of its ends is in the V.P. and 25 mm above the H.P. Draw the projections of the line and determine its inclination with the V.P.*

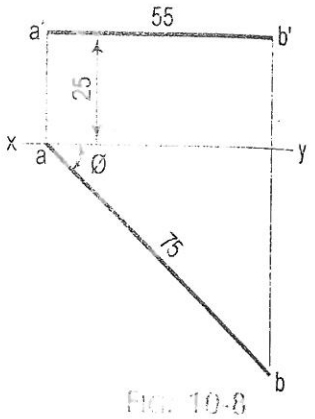


Fig. 10-8

As the line is parallel to the H.P., its front view will be parallel to *xy*.

(i) Mark *a*, the top view of one end in *xy*, and *a'*, its front view, 25 mm above *xy*.

(ii) Draw the front view *a'b'*, 55 mm long and parallel to *xy*. With *a* as centre and radius equal to 75 mm, draw an arc cutting the projector through *b'* at *b*.

Join *a* with *b*. *ab* is the top view of the line. Its inclination with *xy*, viz. ø is the inclination of the line with the V.P.

EXERCISES 10(a)

1. Draw the projections of a 75 mm long straight line, in the following positions:
   - (a) (i) Parallel to both the H.P. and the V.P. and 25 mm from each.
     - (ii) Parallel to and 30 mm above the H.P. and in the V.P.
     - (iii) Parallel to and 40 mm in front of the V.P. and in the H.P.
   - (b) (i) Perpendicular to the H.P., 20 mm in front of the V.P. and its one end 15 mm above the H.P.
     - (ii) Perpendicular to the V.P., 25 mm above the H.P. and its one end in the V.P.
     - (iii) Perpendicular to the H.P., in the V.P. and its one end in the H.P.
   - (c) (i) Inclined at 45° to the V.P., in the H.P. and its one end in the V.P.
     - (ii) Inclined at 30° to the H.P. and its one end 20 mm above it; parallel to and 30 mm in front of the V.P.
     - (iii) Inclined at 60° to the V.P. and its one end 15 mm in front of it; parallel to and 25 mm above the H.P.

2. A 100 mm long line is parallel to and 40 mm above the H.P. Its two ends are 25 mm and 50 mm in front of the V.P. respectively. Draw its projections and find its inclination with the V.P.

3. A 90 mm long line is parallel to and 25 mm in front of the V.P. Its one end is in the H.P. while the other is 50 mm above the H.P. Draw its projections and find its inclination with the H.P.

4. The top view of a 75 mm long line measures 55 mm. The line is in the V.P., its one end being 25 mm above the H.P. Draw its projections.

5. The front view of a line, inclined at 30° to the V.P is 65 mm long. Draw the projections of the line, when it is parallel to and 40 mm above the H.P., its one end being 30 mm in front of the V.P.

6. A vertical line *AB*, 75 mm long, has its end *A* in the H.P. and 25 mm in front of the V.P. A line *AC*, 100 mm long, is in the H.P. and parallel to the V.P. Draw the projections of the line joining *B* and *C*, and determine its inclination with the H.P.

7. Two pegs fixed on a wall are 4.5 metres apart. The distance between the pegs measured parallel to the floor is 3.6 metres. If one peg is 1.5 metres above the floor, find the height of the second peg and the inclination of the line joining the two pegs, with the floor.

PREVIOUS PAPER QUESTIONS

1. **(a)** The top view of a 75mm long line measures 55mm. The line is in the VP; its one end being 25mm above the HP. Draw its projections.

   (b) Draw the projections of the following points on the same ground line, keeping the projectors 25mm apart.

   (i) A, in the HP and 20mm behind the VP

   (ii) B, 40mm above the HP and 25mm in front of the VP

   (iii) C, in the VP and 40mm above the HP.

2. **(a)** A 90mm long line is parallel to and 25mm in front of the VP. Its one end is in the HP while the other is 50mm above the HP. Draw its projections and finds its inclination with HP.

   (b) Two points A and B are in the HP. The point A is 30mm in front of the VP; while B is behind the VP. The distance between their projectors is 75mm and the line joining their top views makes an angle of 45^0 with xy. Find the distance of the point B from the VP**.**

3. **(a)** The front view of a line, inclined at 30^0 to the VP is 65mm long. Draw the projections of the line, when it is parallel to and 40mm above the HP; its one end being 30mm in front of the VP.

   (b) A point P is 20mm below HP and lies in the third quadrant. Its shortest distance from xy is 40mm. Draw its projections.

4. **(a)** A point A is situated in the first quadrant. Its shortest distance from the intersection point of HP; VP and auxiliary plane is 60mm and it is equidistant from the principle planes. Draw the projections of the point and determine its distance from the principle planes.

   (b) A line AB 60mm long is parallel to HP. The point A is 20mm above HP and 35mm in front of VP. The length of the front view is 50mm. Determine the true inclination with VP.

5. **(a)** A point A is situated in the first quadrant. Its shortest distance from the intersection point of HP; VP and auxiliary plane is 60mm and it is equidistant from the principle planes. Draw the projections of the point and determine its distance from the principle planes.

(b) A line MN 50mm long is parallel to VP and inclined at 30^0 to HP. The end M is 20mm above HP and 10mm in front of VP. Draw the projections of the line.

6. **(a)** Draw the orthographic projections of the following points:

   (i) A, 20mm above HP and 30mm behind VP

   (ii) B, 25mm below HP and 25mm in front of VP

   (iii) C, 25mm below HP and 30mm behind VP

   (iv) D, 30mm below HP and in VP

   (b) The top view of a 75mm long line measures 55mm. The line is in the VP; it's one end being 25mm above the HP. Draw its projections.

7. **(a)** A line MN 50mm long is parallel to VP and inclined at 30^0 to HP. The end M is 20mm above HP and 10mm in front of VP. Draw the projections of the line.

   (b) A point P is 20mm below HP and lies in the third quadrant. Its shortest distance from xy is 40mm. Draw its projections.

8. **(a)** Draw the orthographic projections of the following points:

   (i) Point Q is 25mm above HP and 35mm behind VP

   (ii) Point P is 30mm above HP and 40mm in front of VP

   (iii) Point R is32mm below HP and 45mm behind VP

   (iv) Point S is 35mm below HP and 42mm in front of VP

   (b) A line AB 50mm long is perpendicular to VP and parallel to HP. Its end A is 20mm in front of VP and the line is 40mm above HP. Draw the projections of the line.

9. **(a)** A line EF 40mm long is in the VP and inclined to the HP. The top view measures 30mm.The end E is 10mm above the HP. Draw the projections of the line. Determine its inclination with the HP?

   (b) A line RS 40mm long is parallel to both the planes. It is 20 mm above the HP and 15mm in front of the VP. Draw the projections of the line?

10. **(a)** Draw the projections of the following, keeping the distance between the projectors as 25mm on the same reference line:

    (i) A- 25mm above HP and 50mm behind the VP

    (ii) B- 40 mm below HP and 45mm in front of the VP

    (iii) C- on HP and 25mm behind VP

(b) A line CD is parallel to the VP and inclined at 45^0 to the HP. C is in the HP and 25 mm in front of the VP. Top view is 50mm long. Find its true length?

11. **(a)** A point A is 20mm above the HP and in the first quadrant. Its shortest distance from the reference line XY is 40mm. Draw the projections of the point and determine its distance from the VP.

    (b) Draw the projections of line LM 40 mm long, parallel to the HP and inclined at 30^0 to the VP. The L is 20 mm above the HP and 15 mm in front of the VP. Find its traces.

12. **(a)**The top view of a 75mm long line measures 55 mm. The line is in the VP, its one end being 25 mm above the HP. Draw its projections?

    (b) Mark the projections of the following points on projectors 35 mm apart.

    (i) 25 mm above the HP and 40 mm behind the VP

    (ii) 20 mm above the HP and on the VP

    (iii)30 mm below the HP and 45 mm in front of the VP.

13. **(a)** A vertical line AB, 75mm long, has its end A in the HP and 25mm in front of the VP. Another line AC 100mm long is in the HP and parallel to the VP. Draw the projections of the line joining B and C; and determine its inclination with the HP.

    (b) Draw the projections of a straight line AB of 60mm long, in the following positions:

    (i) Perpendicular to the HP and in the VP and one end on the HP

    (ii) Parallel to and 30 mm in front of the VP and on the HP

    (iii) Inclined at 30^0 to the VP, in the HP and one end on the VP.

14. **(a)** A line AB which is perpendicular to the HP and 80mm long has its end B, 20mm below the HP and 30 mm in front of the VP. Another line AC, which is 60mm long, is parallel to both HP and VP. The midpoint D of the line AC is joined to B. Draw the projections and determine the inclination of the line BD with the HP.

    (b) A line PQ 9 cm long is in the HP and makes an angle of 30^0 with the VP. Its end P is 2.5cm in front of the VP. Draw its projections?

15. **(a)** A 90mm long line is parallel to and 25mm in front of the VP. It's one end is in the HP while the other is 50mm above the HP, Draw its projections and find its inclination with the HP?

    (b) A point 30mm above xy line is the plan view of two points P and Q. The elevation of P is 45mm above the HP. While that of the point Q is 35mm below the HP. Draw the

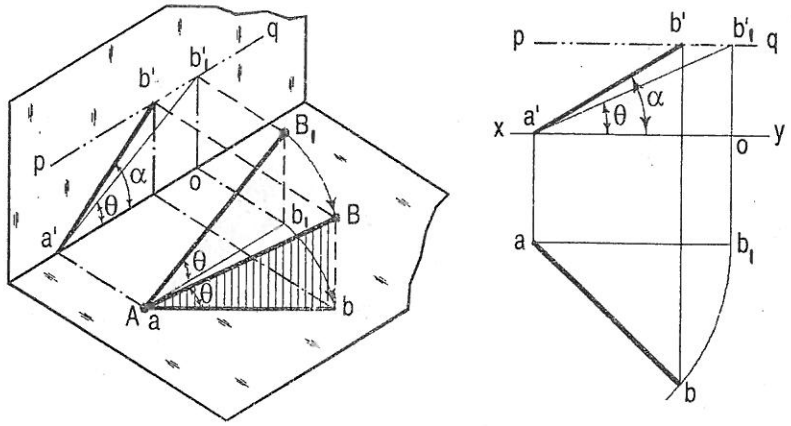
projections of the points and states their position with reference to the principal planes and the quadrant in which they lie?

16. **(a)** An electric switch (A) and Bulb (B), fixed on a wall are 5m apart. The distance between them, measured parallel to the floor is 4m.If the switch is 1.5m above the floor, find the height of the bulb and the inclination of the line joining the switch and the bulb with the floor?

    (b) A 100 mm long line is parallel to and 40 mm above the HP. Its two ends are 25mm and 50mm in front of the VP respectively. Draw its projections and find its inclination with the VP?

LINE INCLINDED TO BOTH PLANES

(a) A line AB_1 (fig. 10-9) is inclined at θ to the H.P. and is parallel to the V.P. The end *A* is in the H.P. AB_1 is shown as the hypotenuse of a right-angled triangle, making the angle θ with the base.



The top view ab_1 is shorter than AB_1 and parallel to *xy*. The front view $a'b'_1$ is equal to AB_1 and makes the angle θ with *xy*.

Keeping the end *A* fixed and the angle θ with the H.P. constant, if the end *B* is moved to any position, say B_2, the line becomes inclined to the V.P. also.

In the top view, b_1 will move along an arc, drawn with *a* as centre and ab_1 as radius, to a position b_2. The new top view *ab* is equal to ab_1 but shorter than *AB*.

In the front view, b'_1 will move to a point b'_2 keeping its distance from *xy* constant and equal to b'_1o; i.e. it will move along the line *pq*, drawn through b'_1 and parallel to *xy*. This line *pq* is the locus or path of the end *B* in the front view. b'_2 will lie on the projector through b_2. The new front view $a'b'_2$ is shorter than $a'b'_1$ (i.e. AB_1) and makes an angle α with *xy*. α is greater than θ.

(b) The same line AB_2 (fig. 10-10) is inclined at ø to the V.P. and is parallel to the H.P. Its end A is in the V.P. AB_2 is shown as the hypotenuse of a right-angled triangle making the angle ø with the base.

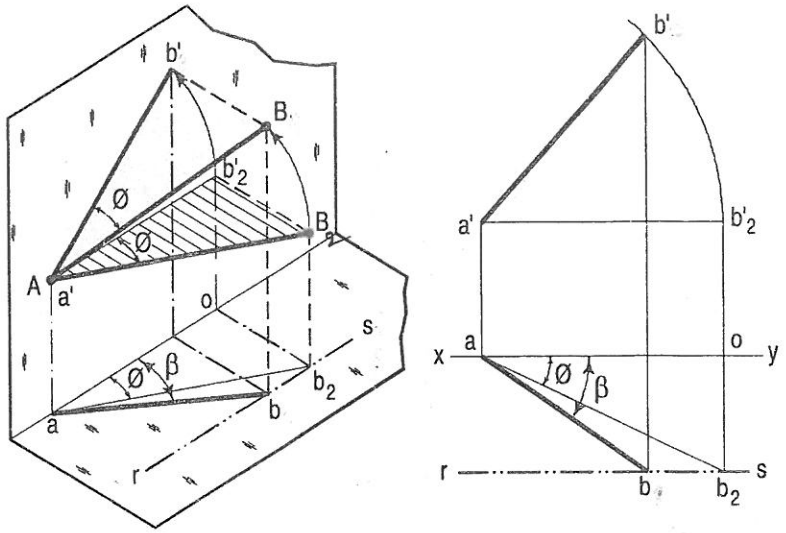


FIG. 10-10

The front view $a'b'_2$ is shorter than AB and parallel to xy. The top view ab_2 is equal to AB and makes an angle ø with xy.

Keeping the end A fixed and the angle ø with the V.P. constant, if B_2 is moved to any position, say B, the line will become inclined to the H.P. also.

In the front view, b'_2, will move along the arc, drawn with a' as centre and $a'b'_2$ as radius, to a position b'. The new front view $a'b'$ is equal to $a'b'_2$ but is shorter than AB.

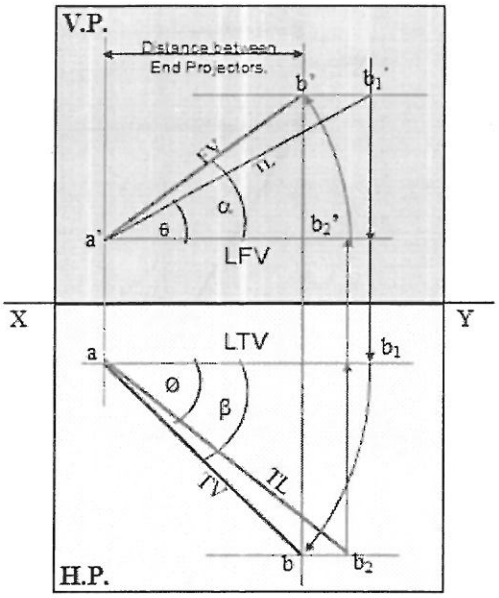
In the top view, b_2 will move to a point b along the line rs, drawn through b_2 and parallel to xy, thus keeping its distance from the path of a, viz. b_2o constant. rs is the locus or path of the end B in the top view. The point b lies on the projector through b'. The new top view ab is shorter than ab_2 (i.e. AB) and makes an angle β with xy. β is greater than ø.

Hence, when a line is inclined to both the planes, its projections are shorter than the true length and inclined to xy at angles greater than the true inclinations. These angles viz. α and β are called apparent angles of inclination.

UNIT-3

LINE INCLINED TO BOTH PLANES

The most important diagram showing graphical relations among all important parameters of this topic.
Study and memorize it as a ***CIRCUIT DIAGRAM***
And use in solving various problems.



1) True Length (TL) – a' b_1' & a b_2
2) Angle of TL with HP - θ
3) Angle of TL with VP – $\mathbf{O}$
4) Angle of FV with xy – α
5) Angle of TV with xy – β
6) Length of FV
7) Length of TV
8) Distance between End Projectors

Important EIGHT parameters to be remembered with Notations used here onward

NOTE this
θ & α Construct with ***a'***
$\mathbf{O}$ & β Construct with ***a***
b' & b_1' on same locus.
b & b_1 on same locus.

Also Remember
True Length is never rotated. It's horizontal component is drawn & it is further rotated to locate view.
Views are always rotated, made horizontal & further extended to locate TL, θ & Ø

PROBLEMS

1. Line AB is 75 mm long and it is 30^0 & 40^0 Inclined to HP & VP respectively. End A is 12mm above Hp and 10 mm in front of VP. Draw projections.

SOLUTION STEPS:

1) Draw xy line and one projector.

2) Locate a' 12mm above xy line & a 10mm below xy line.

3) Take 30^0 angle from a' & 40^0 from a and mark TL i.e. 75mm on both lines. Name those points b_1' and b_2 respectively.

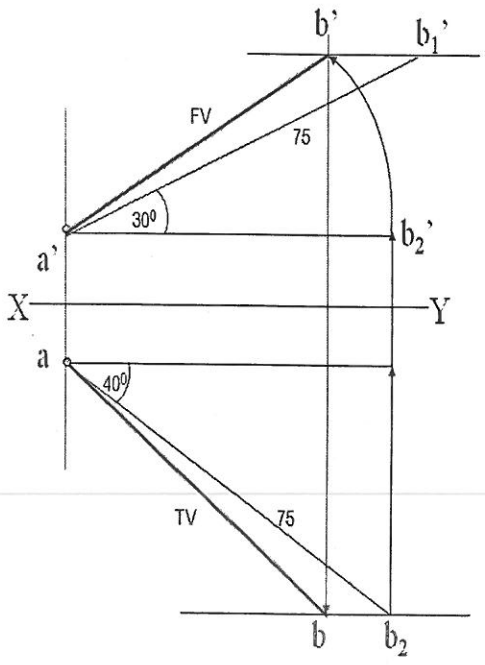
4) Join both b_1' and b_2 points with a' and a respectively.

5) Draw Locus lines from b_1' and b_2 points.

6) project b_2 to b_2' on the line a'b_2'. a'b_2' is the length of AB in the FV.

7) with a' as center and a'b_2' as radius, draw an arc cutting locus line at b' as shown. Join a' b' as Fv.

8) From b' drop a projector downward & get point b. Join a & b i.e. TV.



2. Line AB 75mm long makes 45^0 inclination with VP while it's FV makes 55^0. End A is 10 mm above HP and 15 mm in front of VP. Draw it's projections and find it's inclination with HP.

Solution Steps:-

1.Draw x-y line.

2.Draw one projector for a' & a

3.Locate *a'* 10mm above x-y & *a* 15 mm below xy.

4. Draw a line 45^0 inclined to xy from point *a* and cut TL 75 mm on it and name that point b_2

Draw locus from point b_2

5. Take 55^0 angle from *a'* for Fv and draw a line of some length. The final FV will be on this line.

6. project b_2 to b_2' on the line a'b_2'. a'b_2' is the length of AB in the FV.

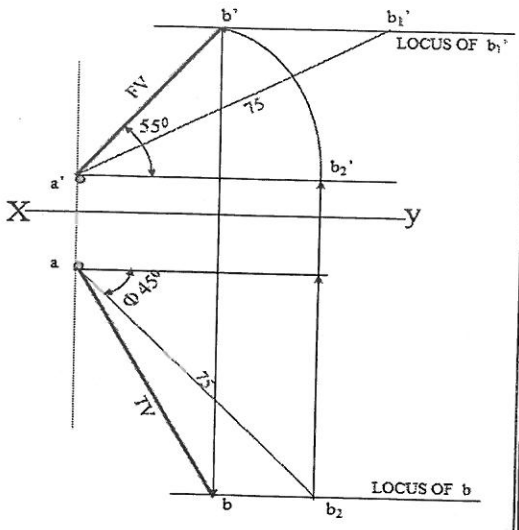
7) with a' as center and a'b_2' as radius, draw an arc cutting the line at b' as shown. Join a' b' as Fv.

8) From b' drop a projector downward & get point b. Join a & b i.e. TV.

9) draw the locus line at b'

10) take true length in compass,with a' as radius cut the locus line passing from b' and mark it as b_1'.join a'b_1' is the true length.

11) And measure the angle at a' with XY line giving the true inclination with HP.



3. FV of line AB is 50^0 inclined to xy and measures 55 mm long while its TV is 60^0 inclined to xy line. If end A is 10 mm above HP and 15 mm in front of VP, draw its projections, find TL, inclinations of line with HP & VP.

SOLUTION STEPS:

1. Draw xy line and one projector.

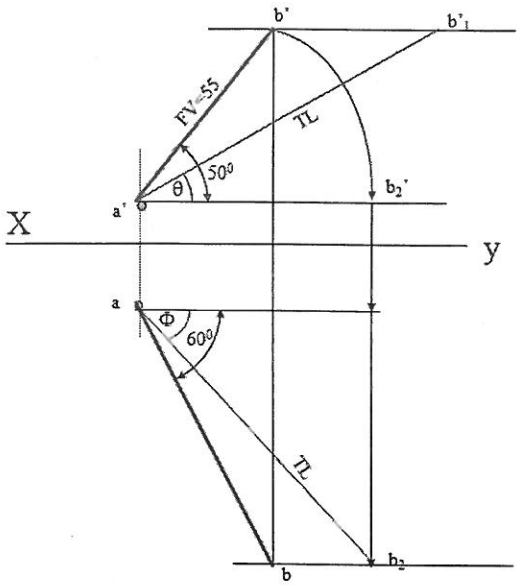
2. Locate a' 10 mm above xy and a 15 mm below xy line.

3. Draw locus from these points.

4. Draw FV 50^0 to xy from a' and mark b' Cutting 55mm on it.

5. Similarly draw TV 60^0 to xy from a & drawing projector from b' Locate point b and join a b.

6. Then rotating views as shown, locate True Lengths ab_2 & $a'b_1'$ and their angles with HP and VP.



4. Line AB is 75 mm long it's FV and TV measure 50 mm & 60 mm long respectively. End A is 10 mm above HP and 15 mm in front of VP. Draw projections of line AB. Find angle with HP and VP. **[16]**
5. A line measuring 80mm long has one of its ends 60mm above HP and 20mm in front of VP. The other end is 15mm above HP and in front of VP. The front view of the line is 60mm long. Draw the top view. **[16]**
6. A line AB is 75mm long. A is 50mm in front of VP and 15mm above HP. B is 15mm in front of VP and is above HP. Top view of AB is 50mm long. Find the front view length and the true inclinations. **[16]**
7. The top view of a line is 65mm long and is inclined at 30^0 to the reference line. One end is 20mm above HP and 10mm in front of VP. The other end is 60mm above HP and in front of VP. Draw the projections and find the true length of the line and its true inclinations to HP and VP. **[16]**
8. A line AB, 65mm long, has its end A 20 mm above the HP and 25 mm in front of the VP. The end B is 40mm above the HP and 65mm in front of the VP. Draw the projections of AB and show its inclinations with the HP and the VP? **[16]**

9. The distance between the projections of two points A and B is 70mm. A is 10mm above HP and 15mm in front of VP. B is 50mm above HP and 40mm in front of VP. Find the shortest distance between A and B by rotating line method. Find true inclinations of AB with VP and HP. **[16]**

10. The midpoint M of a straight line AB is 60mm above HP and 50mm in front of VP. The line measures 80mm long and inclined at an angle of 30^0 to HP and 45^0 to VP. Draw its projections. **[16]**

11. A line AB 120mm long is inclined at 45^0 to HP and 30^0 to VP. Its midpoint C is in VP and 20mm above HP. The end A is in third quadrant and B is in first quadrant. Draw the projections of the line. **[16]**

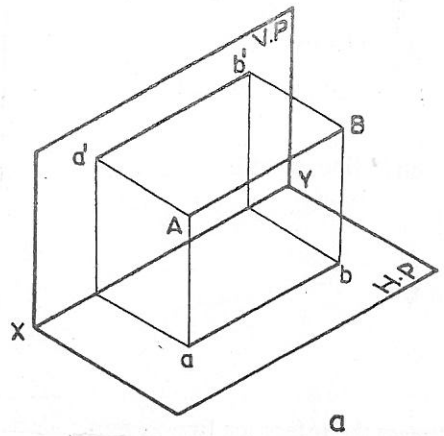
12. The projections of a line measure 80mm in the top view and 70mm in the front view. The mid-point of the line is 45mm in front of VP and 35mm above HP. One end is 10mm in front of VP and nearer to it. Draw the projections. Find true length and true inclinations with reference planes. **[16]**

Traces of a line:

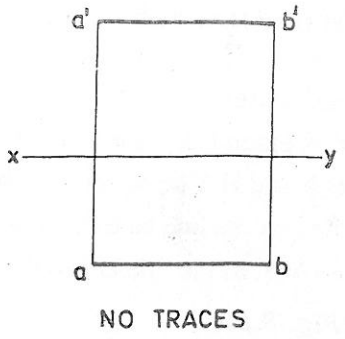
- The trace of a line is defined as a point at which the given line, if produced, meets or intersects a plane.
- When a line meets HP, (or if necessary on the extended portion-of HP), the point at which the line meets or intersects the horizontal plane, is called horizontal trace (HT) of the line and denoted by the letter H.
- When a line meets VP (or if necessary on the extended portion of VP), the point at which the line meets or intersects the vertical plane, is called vertical trace (VT) of the line and denoted by the letter V.

1. *Line is parallel to both HP and VP*

When a straight line is parallel to both H.P and V.P, the line will not meet the plane of projection, even when it is extended. Therefore, there are no traces for the line



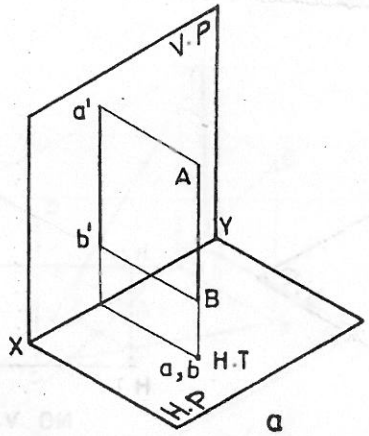
a



b

2. *Line is perpendicular to HP and parallel to VP*

In this case, H.T of the line will coincide with the top view of the line and there is no V.T, as the line is parallel to V.P



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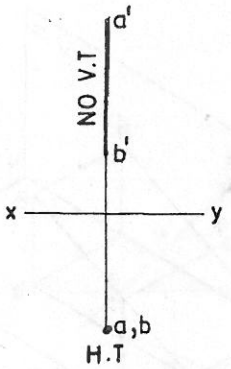

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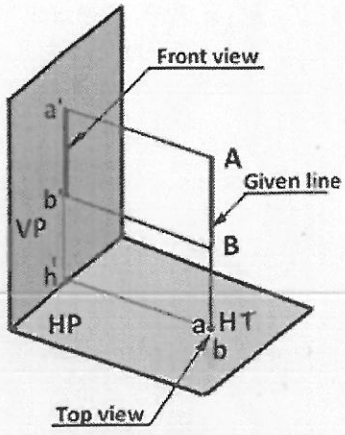
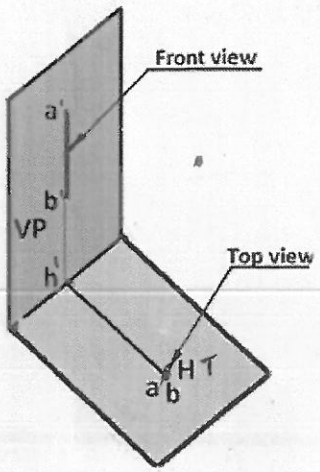
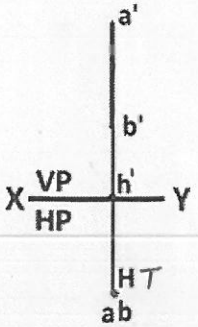
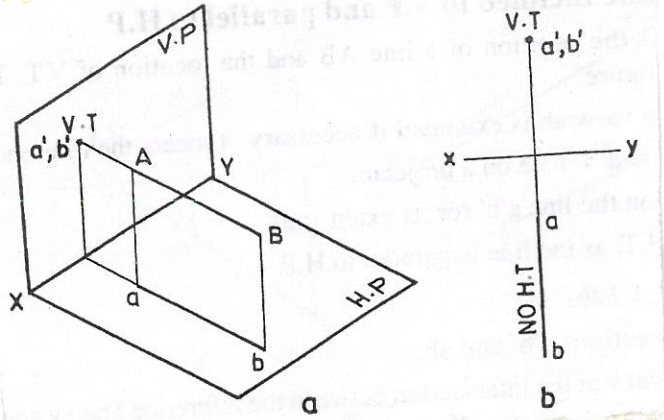


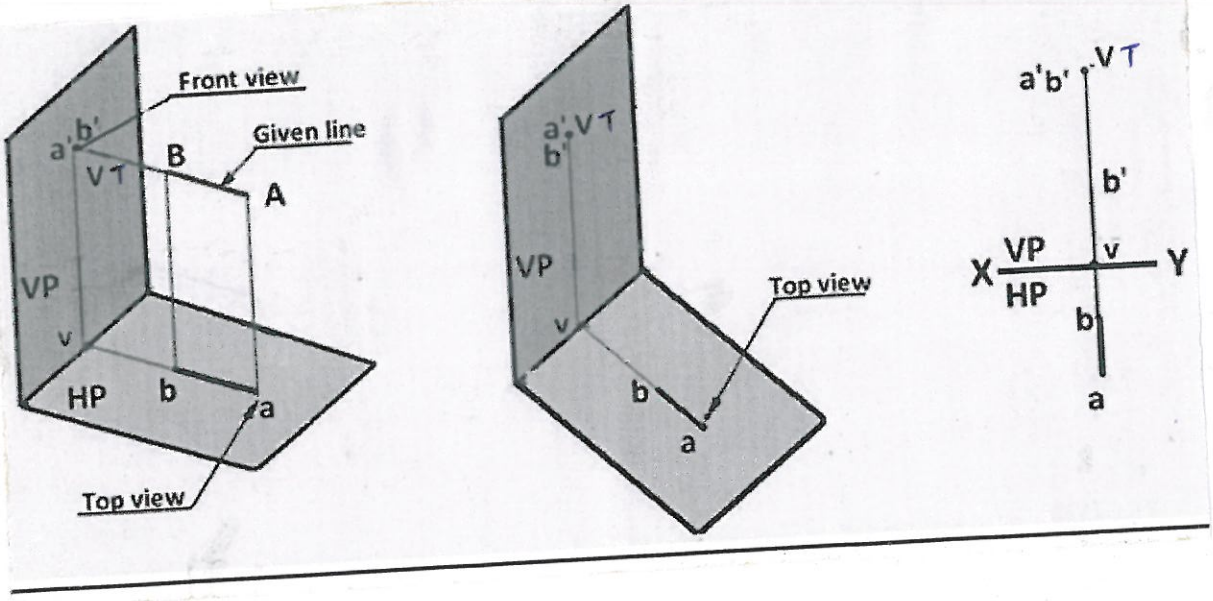




3. *Line is perpendicular to VP and parallel to HP*

In this case, V.T of the line will coincide with the front view of the line and there is no H.T, as the line is parallel to H.P





4. *Line is inclined to HP and parallel to VP*

Referring to Fig. [illegible], the line BA when extended will meet H.P at H.T. The following may be observed from the figure:

(i) When b'a' is extended, it meets the reference line xy at h.

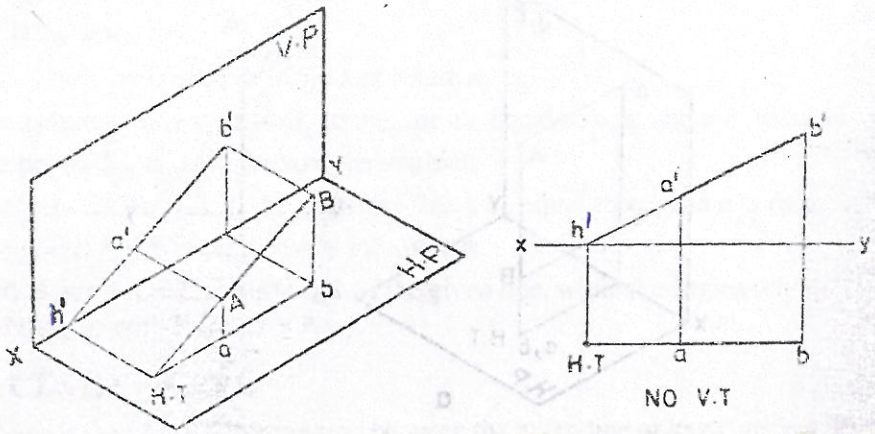
(ii) The points h' and H.T lie on a projector.

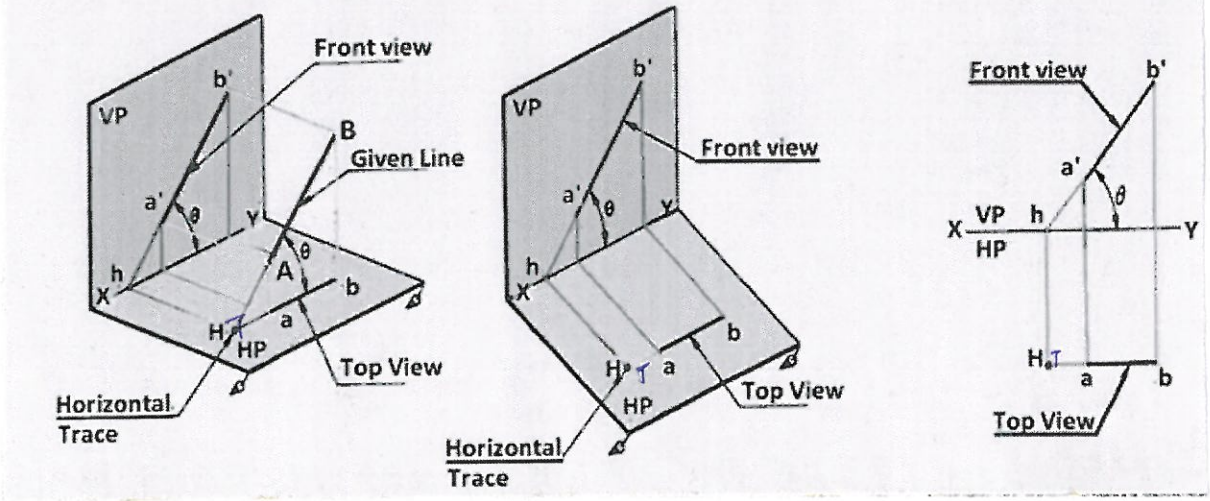
(iii) The H.T lies on the line ba extended.

(iv) There is no V.T, as the line is parallel to V.P.

Construction

1. Draw the projections a'b' and ab.
2. Locate the point h' at the intersection between the reference line xy and b'a' (or its extension).
3. Locate H.T at the intersection between a projector drawn from h' and the top view ba (or its extension).





5. *Line is inclined to VP and parallel to HP*

Figure shows the position of a line AB and the location of V.T. The following may be observed from the figure:

(i) When the top view ab is extended if necessary, it meets the reference line xy at V.

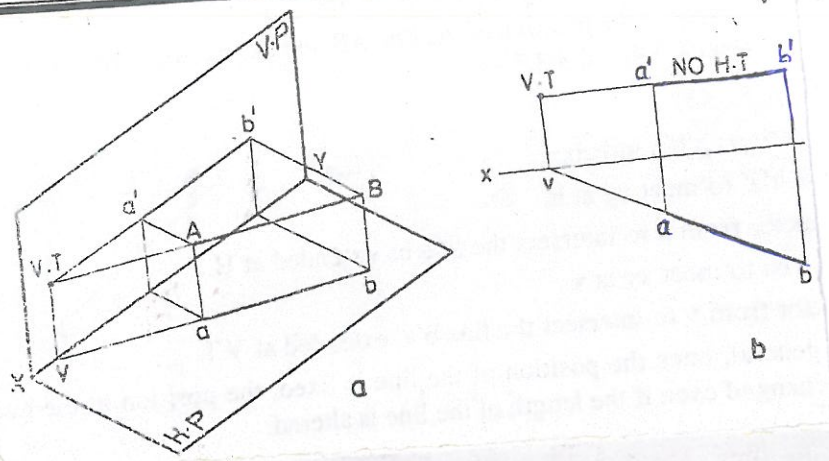
(ii) The points v and V.T lie on a projector.

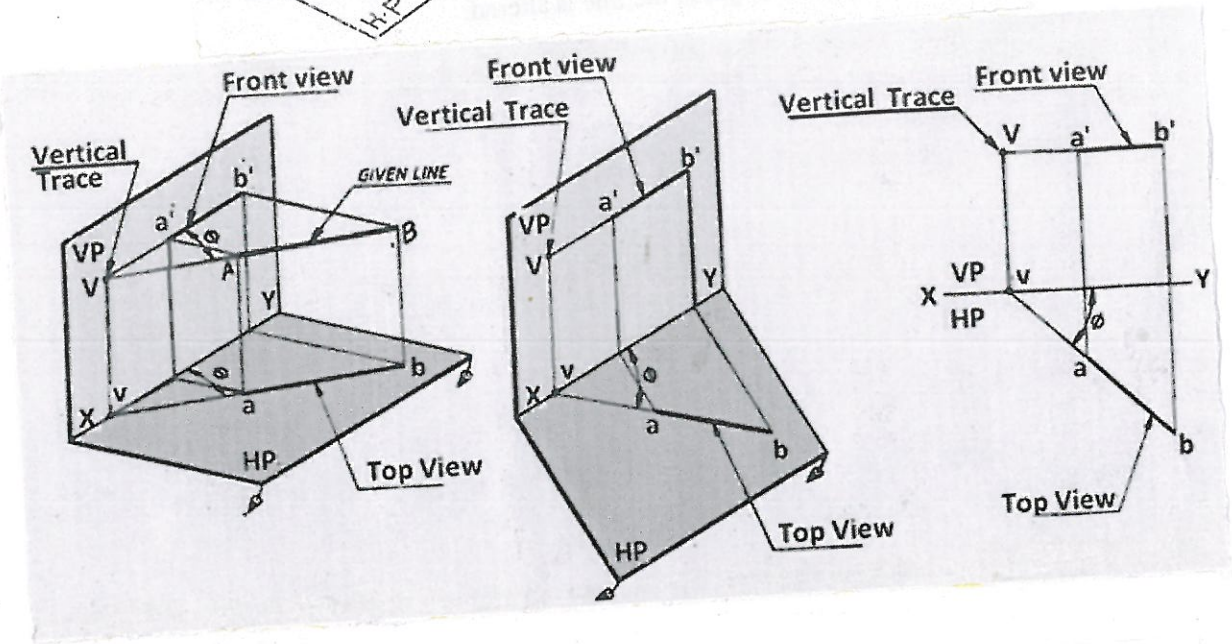
(iii) The V.T lies on the line a'b' (or its extension).

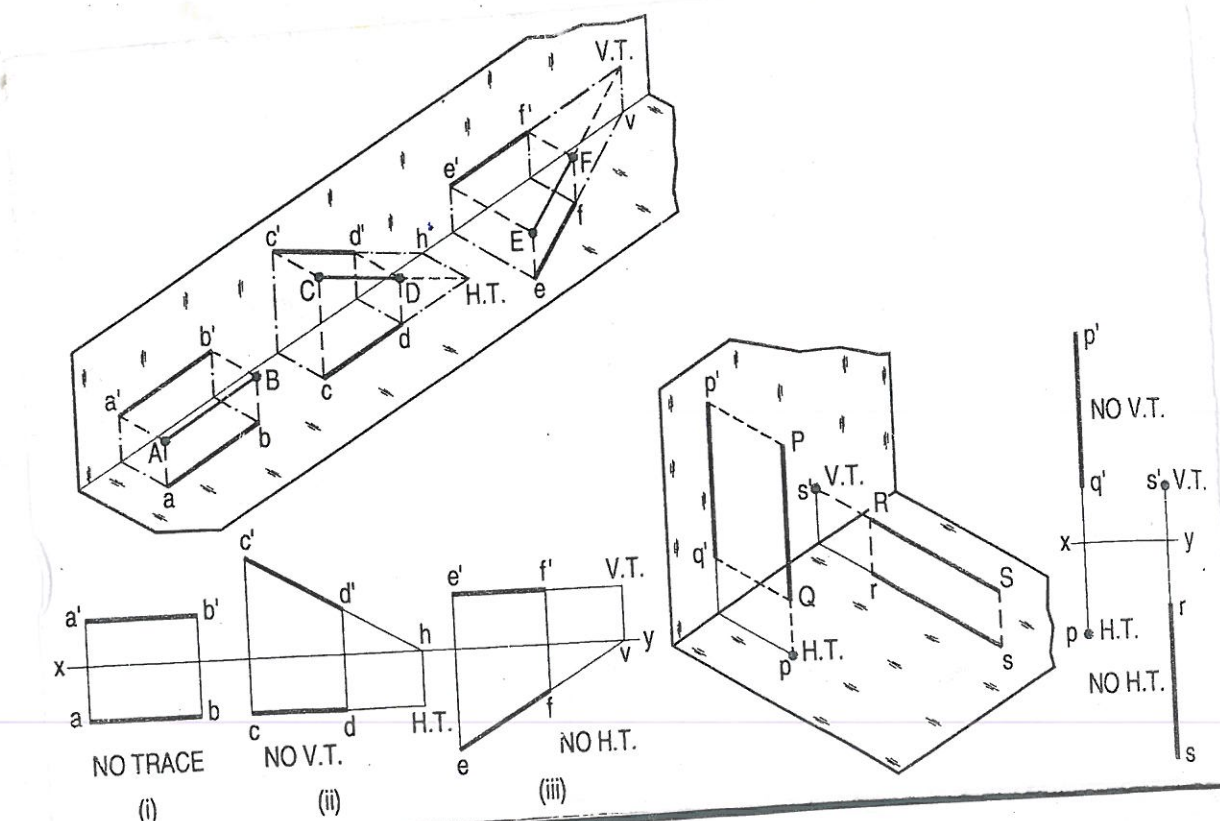
(iv) There is no H.T, as the line is parallel to H.P.

Construction

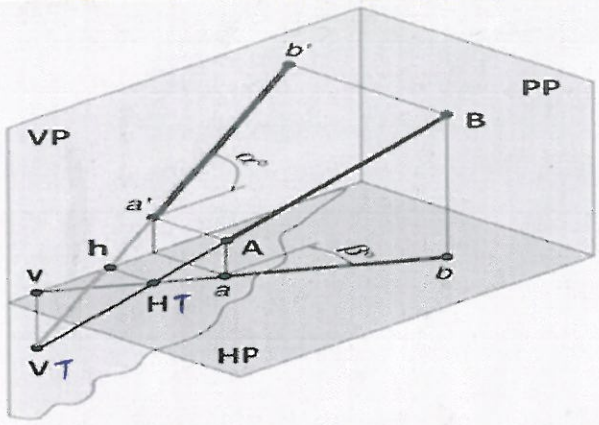
1. Draw the projections a'b' and ab.
2. Locate the point v at the intersection between the reference line xy and ba (or its extension)
3. Locate V.T at the intersection between a projector drawn from v and the front view b'a' (or its extension).

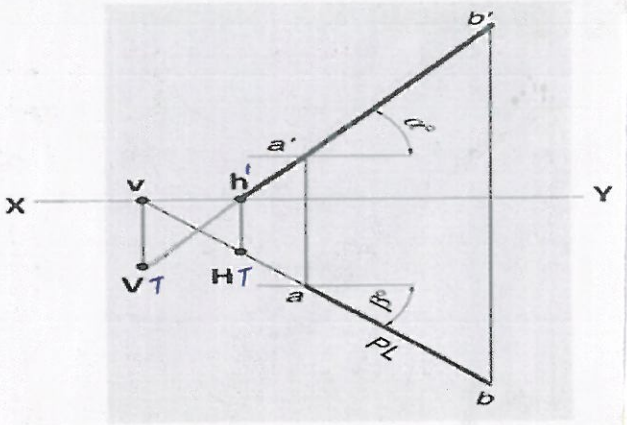

V.P
b'
a'
A
B
V.T
a
b
x
v
H.P
a
V.T
a' NO H.T
b'
x
v
a
b
b


Front view
Vertical Trace
GIVEN LINE
VP
V
a'
b'
A
B
Y
X
v
a
b
HP
Top View
Front view
Vertical Trace
VP
V
a'
b'
Y
X
v
a
b
HP
Top View
Vertical Trace
Front view
V
a'
b'
VP
v
Y
X
HP
a
b
Top View


V.T.
f'
v
e'
F
f
c'
d'
h'
E
C
D
H.T.
e
b'
B
c
d
a'
A
b
a
c'
d'
h
a'
b'
x
a
b
c
d
H.T.
NO TRACE
NO V.T.
(i)
(ii)
e'
f'
V.T.
y
v
f
e
NO H.T.
(iii)
p'
P
s'
V.T.
R
q'
S
Q
r
p
H.T.
s
p'
NO V.T.
q'
s'
V.T.
x
y
r
p
H.T.
NO H.T.
s

6. *Line is inclined to both planes (HP and VP)*



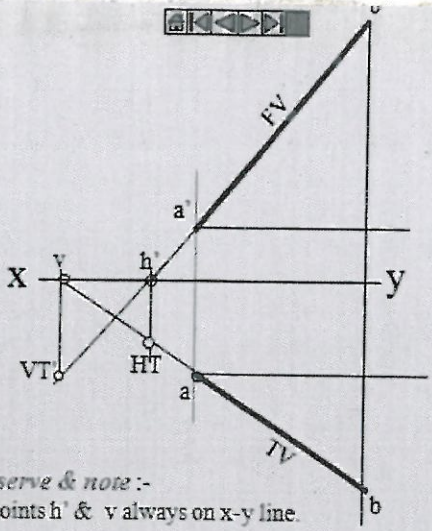


STEPS TO LOCATE HT.
(WHEN PROJECTIONS ARE GIVEN.)

1. Begin with FV. Extend FV up to XY line.
2. Name this point **h'**
   (as it is a Fv of a point in HP)
3. Draw one projector from **h'.**
4. Now extend Tv to meet this projector.
   This point is HT

STEPS TO LOCATE VT.
(WHEN PROJECTIONS ARE GIVEN.)

1. Begin with TV. Extend TV up to XY line.
2. Name this point **V**
   (as it is a Tv of a point in VP)
3. Draw one projector from **v.**
4. Now extend Fv to meet this projector.
   This point is VT



Observe & note :-

1. Points h' & v always on x-y line.
2. VT' & v always on one projector.
3. HT & h' always on one projector.
4. FV - h' - VT always co-linear.
5. TV - v - HT always co-linear.

*These points are used to solve next **three** problems.*

8.3.6.1 Special cases of traces

Case I A line AB is inclined to both H.P and V.P and has its end A in H.P and end B in V.P.

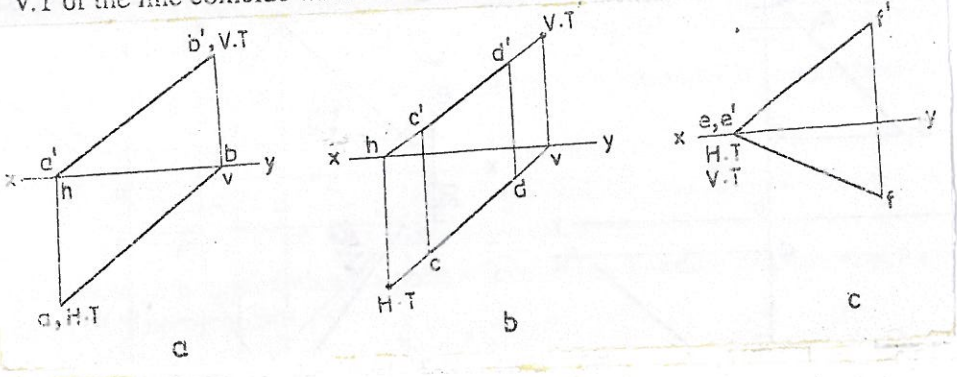
Figure 8.16a shows the projections of a line. From the figure, it is clear that H.T of the line coincides with a, the top view of A and V.T coincides with b', the front view of B.

Case II Same as Case I, but the line AB is shortened from both its ends and occupying the position CD.

Figure 8.16b shows the projections of the line along with the traces located. From the figure, it is clear that the traces of the line CD are still the same as those for Case I.

Case III A line EF is inclined to both H.P and V.P and has its end E on both H.P and V.P.

Figure 8.16c shows the projections of the line. From the figure, it is clear that H.T and V.T of the line coincide with e and e', the projections of the end point E.



PROBLEMS ON TRACES

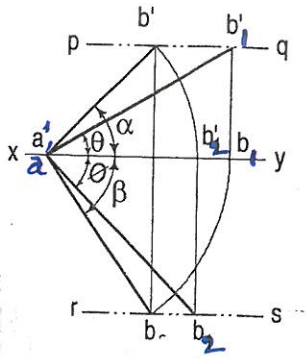
1. FV of line AB makes 45^0 angle with XY line and measures 60 mm. Line's TV makes 30^0 with XY line. End A is 15 mm above HP and its VT is 10 mm below HP. Draw projections of line AB and determine inclinations with HP & VP and locate HT, VT.
2. One end of line AB is 10mm above HP and other end is 100 mm in-front of VP. Its Fv is 45^0 inclined to xy while its HT & VT are 45mm and 30 mm below xy respectively. Draw projections and find TL with its inclinations with HP & VP.
3. A straight line AB of 75mm long has the end Aon VP and the end B on HP .The line is inclined at 30^0 to the VP and its front view makes an angle of 45^0 with xy. Draw the projections of the line and add the left side view and locate the traces?
4. A line AB inclined 30^0 to the VP, has its ends 50mm and 20mm above the HP. The length of its front view is 65mm and its VT is 10 mm above the HP. Determine the true length of AB, its inclination with the HP and its HT?

EXAMPLES

Problem : *A line AB, 50 mm long, has its end A in both the H.P. and the V.P. It is inclined at 30° to the H.P. and at 45° to the V.P. Draw its projections.*

As the end *A* is in both the planes, its top view and the front view will coincide in *xy*.

(i) Assuming *AB* to be parallel to the V.P. and inclined at θ (equal to 30°) to the H.P., draw its front view ab_1' (equal to *AB*) and project the top view ab_1.



(ii) Again assuming *AB* to be parallel to the H.P. and inclined at ø (equal to 45°) to the V.P., draw its top view ab_2 (equal to *AB*). Project the front view ab_2'.

ab_1 and $a'b_1'$ are the lengths of *AB* in the top view and the front view respectively, and *pq* and *rs* are the loci of the end *B* in the front view and the top view respectively.

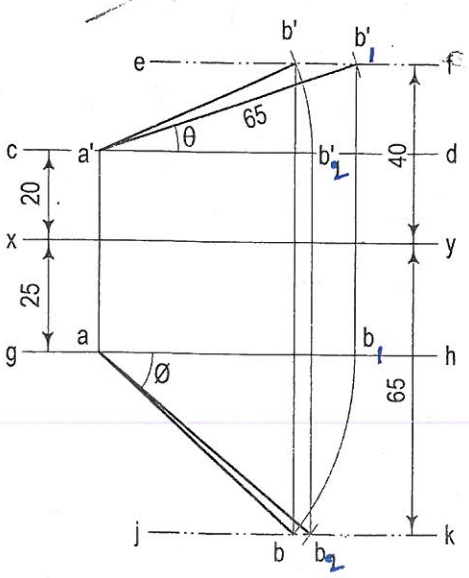
(iii) With *a* as centre and radius equal to $a'b_1'$, draw an arc cutting *pq* in *b'*. With the same centre and radius equal to ab_1, draw an arc cutting *rs* in *b*.

Draw lines joining *a* with *b'* and *b*. $a'b'$ and *ab* are the required projections.

Problem : *A line AB, 65 mm long, has its end A 20 mm above the H.P. and 25 mm in front of the V.P. The end B is 40 mm above the H.P. and 65 mm in front of the V.P. Draw the projections of AB and show its inclinations with the H.P. and the V.P.*

(i) As per given positions, draw the loci *cd* and *gh* of the end *A*, and *ef* and *jk* of the end *B* in the front view and the top view respectively.

(ii) Mark any point *a* (the top view of *A*) in *gh* and project it to *a'* on *cd*. With *a'* as centre and radius equal to 65 mm, draw an arc cutting *ef* in b_1'. Join *a'* with b_1'. θ, the inclination of $a'b_1'$ with *xy*, is the inclination of *AB* with the H.P. Project b_1' to b_1 on *gh*. ab_1 is the length of *AB* in the top view.



(iii) With a as centre and radius equal to 65 mm, draw an arc cutting jk in b_2. Join a with b_2. ø, the inclination of ab_2 with xy, is the inclination of AB with the V.P. Project b_2 to b'_2 on cd. $a'b'_2$ is the length of AB in the front view.

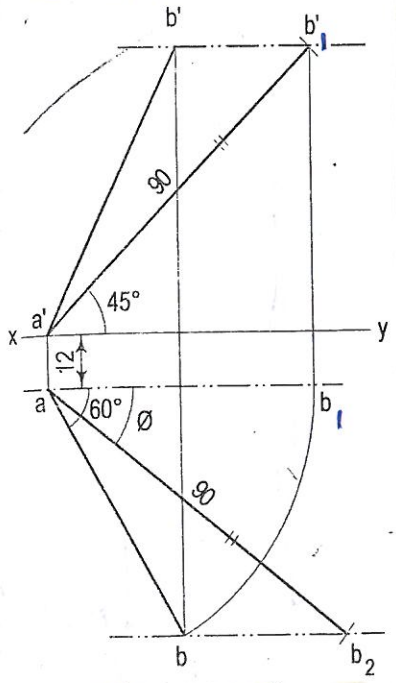
Arrange ab_1 and $a'b'_2$ between their respective paths as shown. $a'b'$ and ab are the required projections of AB.

Problem : *A line AB, 90 mm long, is inclined at 45° to the H.P. and its top view makes an angle of 60° with the V.P. The end A is in the H.P. and 12 mm in front of the V.P. Draw its front view and find its true inclination with the V.P.*

(i) Mark a and a', the projections of the end A.

(ii) Assuming AB to be parallel to the V.P. and inclined at 45° to the H.P., draw its front view $a'b'_1$ equal to AB and making an angle of 45° with xy. Project b'_1 to b_1 so that ab_1 the top view is parallel to xy. Keeping the end a fixed, turn the top view ab_1 to a position ab so that it makes an angle of 60° with xy. Project b to b' on the locus of b'_1. Join a' with b'. $a'b'$ is the front view of AB.

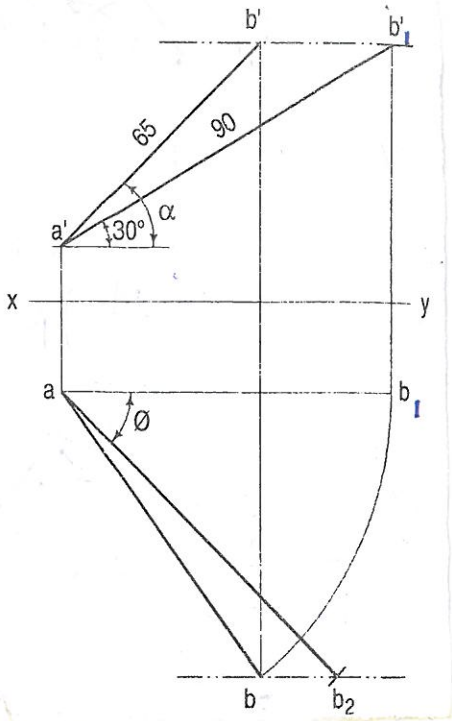
(iii) To find the true inclination with the V.P., draw an arc with a as centre and radius equal to AB, cutting the locus of b in b_2. Join a with b_2. ø is the true inclination of AB with the V.P.



Problem : *A line AB, 90 mm long, is inclined at 30° to the H.P. Its end A is 12 mm above the H.P. and 20 mm in front of the V.P. Its front view measures 65 mm. Draw the top view of AB and determine its inclination with the V.P.*

(i) Mark *a* and *a'* the projections of the end *A*. Through *a'*, draw a line $a'b_1'$, 90 mm long and making an angle of 30° with *xy*.

(ii) With *a'* as centre and radius equal to 65 mm, draw an arc cutting the path of b_1' at *b'*. *a'b'* is the front view of *AB*.



(iii) Project b_1' to b_1, so that *ab* is parallel to *xy*. ab_1 is the length of *AB* in the top view.

(iv) With *a* as centre and radius equal to ab_1, draw an arc cutting the projector through *b'* at *b*. Join *a* with *b*. *ab* is the required top view.

Problems on Traces

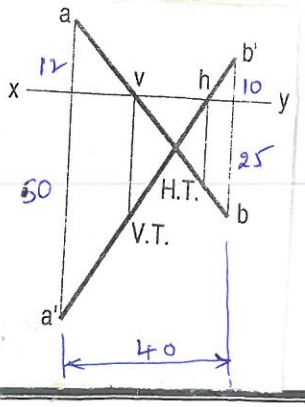
Problem . *A point A is 50 mm below the H.P. and 12 mm behind the V.P. A point B is 10 mm above the H.P. and 25 mm in front of the V.P. The distance between the projectors of A and B is 40 mm. Determine the traces of the line joining A and B.*

Draw the projections *ab* and *a'b'* of the line *AB*.

Method :

(i) Through *v*, the point of intersection between *ab* and *xy*, draw a projector to meet *a'b'* at the V.T. of the line.

(ii) Similarly, through *h*, the point of intersection between *a'b'* and *xy*, draw a projector to cut *ab* at the H.T. of the line.



Problem : *The projectors of the ends of a line AB are 50 mm apart. The end A is 20 mm above the H.P. and 30 mm in front of the V.P. The end B is 10 mm below the H.P. and 40 mm behind the V.P. Determine the true length and traces of AB, and its inclinations with the two planes.*

Draw two projectors 50 mm apart. On one projector, mark the top view *a* and the front view *a'* of the end *A*. On the other, mark the top view *b* and the front view *b'* of the end *B*, as per given distances. *ab* and *a'b'* are the projections of *AB*.

By making the line parallel to a plane (fig. 10-37):

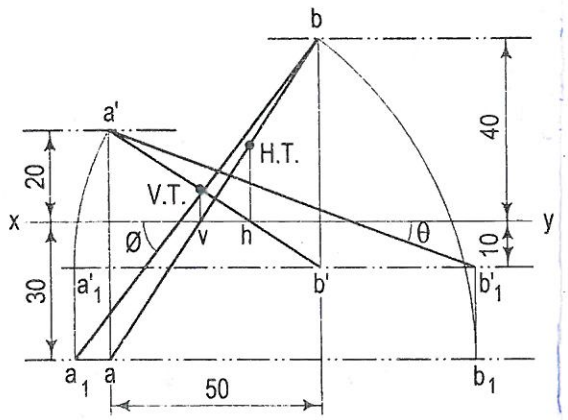
(i) Keeping *a* fixed, turn *ab* to a position ab_1, thus making it parallel to *xy*. Project b_1 to b'_1 on the locus of *b'*. $a'b'_1$ is the true length of *AB* and θ is its true inclination with the H.P.

(ii) Similarly, turn *a'b'* to the position a'_1b' and project a'_1 to a_1 on the path of *a* (because the end *a* has been moved). a_1b is the true length of *AB* and ϕ is its inclination with the V.P.

Traces:

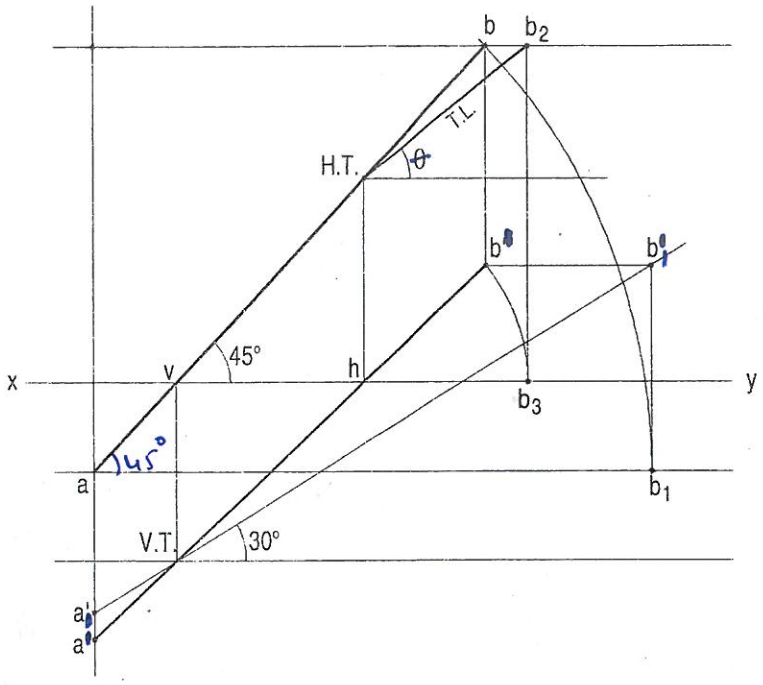
(i) Through *v* the point of intersection of the top view *ab* with *xy*, draw a projector to cut *a'b'* at the V.T.

(ii) Through *h* the point of intersection of the front view *a'b'* with *xy*, draw a projector to cut *ab* at the H.T. of the line.



Problem . *The straight line AB is inclined at 30° to H.P., while its top view at 45° to a line xy. The end A is 20 mm in front of the V.P. and it is below the H.P. The end B is 75 mm behind the V.P. and it is above the H.P. Draw the projections of the line when its V.T. is 40 mm below. Find the true length of the portion of the straight line which is in the second quadrant and locate its H.T.*

Refer to fig. 10-50.



T.L. = 50 mm. ∠V.P., θ = 37°

FIG. 10-50

(i) Mark the points *a* (top view of *A*) and *b* (top view of *B*) at the distances of 20 mm and 75 mm below and above *xy* respectively.

(ii) Through the point *a*, draw a line at 45° intersecting *xy* and the path of *b* at *v* and *b* respectively as shown.

(iii) Construct a line containing V.T. 40 mm below *xy*. Draw perpendicular from *v* to the line V.T.

(iv) With *a* as centre and radius equal to *ab*, draw an arc which intersects at b_1 a line drawn from *a* parallel to *xy*. From V.T. draw a line at 30° intersecting the projector of b_1 at b'_1. From b'_1, draw $b''b'$ parallel to *xy* to intersect projector of *b* at b'. Join V.T. b'. Produce it to meet the projector from *a* at a'. $a'b'$ is the required projection. $a'b'$ intersects line *xy* at *h*. From *h* draw the perpendicular to meet *ab*. The intersection point represents H.T.

(v) With *h* as centre and radius equal to hb', draw an arc intersecting at b_3. Draw projector from b_3 to cut the path of *b* at b_2. Join H.T. b_2. Measure the angle H.T. b_2 with *xy*. This is an angle made by the line with the V.P.