Sections of Solids 14

14.1. INTRODUCTION

So for we have studied that the shape of an object can be described by drawing its orthographic views, in which the visible features are drawn by firm lines and invisible details are drawn by dotted lines. When the invisible lines of hidden features are many, a large number of dotted lines, drawn to represent them renders the views more confusing and hard to read. In such cases we should resort to sectioning, *i.e.*, a part of the object , being drawn, is imagined to be cut away by a section or cutting plane so as to expose its interior (hidden) details. The part of the object between the cutting plane and the observer is assumed to be removed. The exposed interior details are then drawn in full lines instead of hidden detail lines. The resulting view is a sectional view or a section. Strictly, a sectional view includes all visible lines behind the section plane, while a section only shows what appears on the cutting and does not include any part of the object, which is visible beyond the section plane. A section, as opposed to a sectional view, is rarely used in engineering drawing, and frequently the two terms are used indiscriminately. The reader of a drawing recognizes a section because it is indicated by drawing thin section lines, uniformly spaced, and usually inclined at 45° to the reference line.

Methods of drawing the sectional views and auxiliary sections are same as have been used in chapters on projections of solids and auxiliary projections. Here, in this chapter, we shall develop the basic geometric principles used to draw sectional views and auxiliary sections of simple solids.

14.2. SECTION PLANES

In addition to the principal planes, HP and VP, it is customary to picture the auxiliary planes, when drawing auxiliary or sectional views. Section planes are usually perpendicular planes. They may be perpendicular or parallel to one of the principle planes and either perpendicular or inclined to the other plane. These planes are represented by their traces, as already explained in chapter 11.

14.3. APPARENT SECTION

The projection of a section on the principal plane to which the section plane is perpendicular is a straight line coinciding with the trace of the section plane on it. Whereas its projection on the principal plane to which it is inclined is *apparent section*, *Fig. 14.14*.

14.4. TRUE SECTION

The projection of the section obtained on a plane parallel to the section plane, which is same as the section exposed by the section plane, is called the *true section*. If the section plane be parallel to the HP or ground plane, the true shape of the section is projected in sectional top view, *Fig. 14.2*. Whereas, the true shape of the section is shown in sectional front view when the section plane is parallel to the VP, *Fig. 14.7*.

When the section plane is inclined to one of the principal planes and perpendicular to the other, *i.e.*, AIP or AVP, the true shape of the section is obtained by projecting on an auxiliary plane, parallel to the section plane, *Figs. 14.15, 14.23*.

A Draw the sectional F.V → cut at T.V
B Draw the sectional T.V — cut at F.V

When the section plane is perpendicular to both principal planes, the sectional end view show the true shape of the section, *Fig. 14.31.*

14.5. TYPES OF SECTIONS OF SOLIDS

By using the five different types of perpendicular section planes we obtain the following five types of sectional views of solids:

1. *Sections of solids obtained by* ***horizontal planes.***
2. *Sections of solids obtained by* ***vertical planes.***
3. *Sections of solids obtained by* ***auxiliary inclined planes.***
4. *Sections of solids obtained by* ***auxiliary vertical planes.***
5. *Sections of solids obtained by* ***profile planes.***

14.6. PROCEDURE FOR DRAWING A SECTIONAL VIEW

The projections of all the solids are first drawn in thin lines without imagining them to be cut or sectioned as desired. Then, after the projections of the complete solids are drawn the trace, to represent the section plane, is passed through the appropriate view, as given in the problem. The part of the solid, in between the observer and the section plane, is assumed to be cut away. Then the projections of points lying on the boundary of the section are projected from the view through which the trace for the section plane is passed to the other corresponding view showing section. If the section plane line is passed through the front view then the top view is drawn in section and vice versa. Further, the part of the solid, which is supposed to be cut away, is drawn in *thin continuous* or *preferably in thin short double chain lines.*

In connection with the section lining the following points should be kept in mind:

1. Section lines should be thin continuous lines, usually inclined at 45° to XY line.
2. The distance between any two consecutive section lines, in a sectional area, should be approximately equal.
3. The boundary of a sectioned area should always be firm.
4. There should be no firm lines inside the boundary of a sectioned area.
5. Direction of section lines should be same, in a sectioned area, in all its views.

We should now consider the cases where the solids are cut by the five types of perpendicular section planes, in turn.

14.7. SECTION PLANE PERPENDICULAR TO VP AND PARALLEL TO HP

Figure 14.1 shows a right regular pentagonal pyramid cut by a section plane perpendicular to VP and parallel to HP. The plane has only VT and has no HT. As the section plane is parallel to the HP, projection of the section on the HP is true shape and size. Its projection on the VP is a line and it coincides with the VT of the plane. The pictorial view illustrates the theory of projection of sectional views.

To have more close insight of the principles involved, the following problems, using such a section plane, should be carefully studied.

PROBLEM 14.1. *A right regular pentagonal pyramid, side of base 30 mm and height 52 mm, rests on its base in HP with one of its base edges perpendicular to VP. A section plane parallel to the HP cuts the axis of the pyramid at a distance of 25 mm from its base. Draw its front view and sectional top view.*

SOLUTION: Refer *Fig. 14.1.*

As the pyramid has its base on HP, draw the top view keeping one of the sides of base perpendicular to XY line. Then project its corresponding front view. Name the points in top and front views, as shown.

As the section plane is parallel to the HP, it is perpendicular to the VP. It is represented by its VT, drawn through the front view at a distance of 25 mm from the XY line and parallel to it. The slant edges **o′1′**, **o′2′**, **o′3′**, **o′4′** and **o′5′** are cut, respectively, at points **a′**, **b′**, **c′**, **d′**, and **e′** in front view. These points are projected downwards to cut their corresponding edges **o**1, **o**2, **o**3, **o**4, and **o**5 in top view at points **a, b, c, d,** and **e**. When mutually joined, these points give smaller regular pentagon, placed centrally inside the pentagon for the base of the pyramid. The smaller pentagon represents the true section here. Remove or leave as thin double chain lines the projections of the cut away part OABCDE of the pyramid in the two

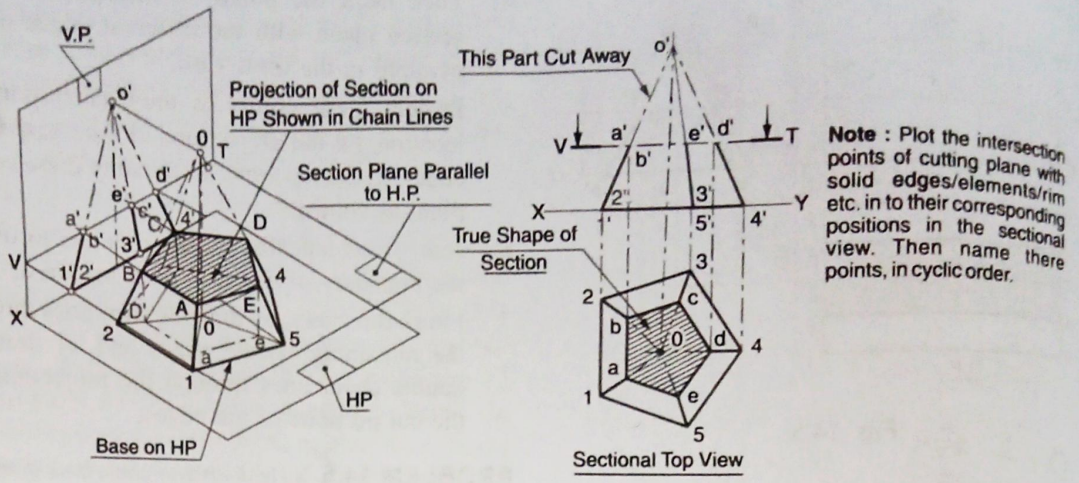

Fig. 14.1.

views, and make the rest of the projections of the pyramid bold, to complete the two required views.

PROBLEM 14.2. *A right regular hexagonal pyramid, side of base 30 mm and height 70 mm, rests on its base in HP, with one of its base edges parallel to VP. An auxiliary horizontal plane parallel to the HP and perpendicular to the VP cuts the pyramid at a height of 34 mm from the base. Draw its front view and sectional top view.*

SOLUTION: Refer *Fig. 14.2.*

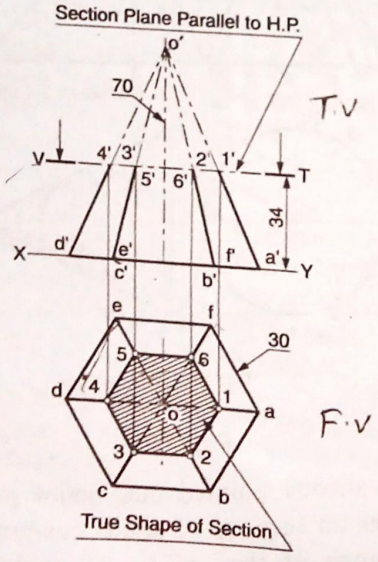

Fig. 14.2. First Angle Projection

- Draw the projections of the pyramid, starting at top view and name the corner points, as shown.
- Draw the VT to represent the section plane, at a distance of 34 mm from XY line and parallel to it.
- Project the points of intersection **1′, 2′, 3′, 4′, 5′,** and **6′** of the cutting plane with the six slant edges **o′a′, o′b′, o′c′, o′d′, o′e′** and **o′f′** respectively, to their corresponding projections **oa, ob, oc, od, oe,** and **of** in the top view, as 1, 2, 3, 4, 5 and 6. Join these six points mutually to represent the section as shown and draw section lines in it.
- The projection of the section in the top view is true shape and size as the section plane is parallel to the HP.

PROBLEM 14.3. *A triangular prism, side of base 45 mm and length of axis 75 mm, is lying on one of its rectangular faces in HP. Its axis is parallel to both HP and VP. It is cut by a section plane parallel to and at a distance of 22 mm from the HP. Draw its front view and sectional top view.*

SOLUTION: Refer *Fig. 14.3.*

As the triangular end face, in the given position, is not parallel to either of the HP and VP, beginning can not be made from the front or top views. Instead, the end face is parallel to a profile plane. Therefore, draw the side view first, as shown, and then project the front and top views from it.

Draw the cutting plane line VT parallel to XY line and 22 mm away from it. The section is a rectangle. The depth dimension (D here) is transferred from the side view to the top view, as shown.

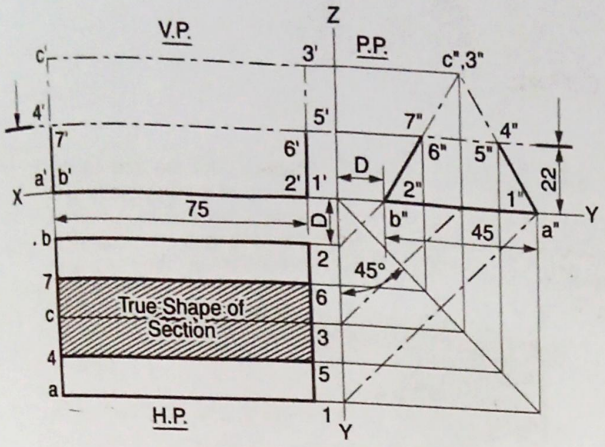

Fig. 14.3.

PROBLEM 14.4. *A right regular pentagonal pyramid, side of base 30 mm and height 65 mm, lies on one of its triangular faces in HP. Its axis is parallel to VP. A section plane, perpendicular to the VP and parallel to the HP, cuts its axis at a point P which is 7 mm away from its base. Draw its front view and sectional top view.*

SOLUTION: Refer *Fig. 14.4.*

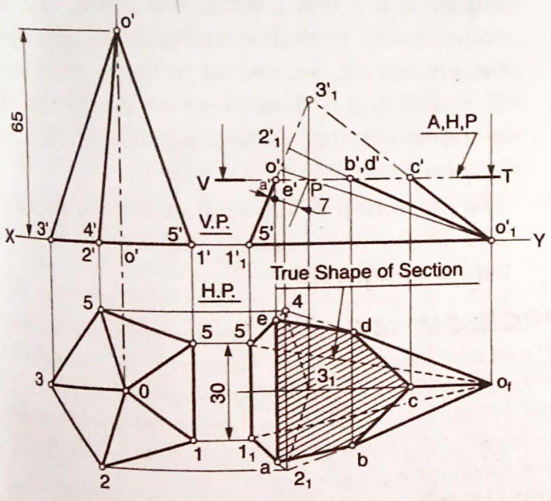

Fig. 14.4. First Angle Projection

1. Draw the projections of the given pyramid, in thin lines, and name the various corner points as illustrated.
2. In the front view, at a distance of 7 mm from the base and along the axis (TL here), plot a point P.
3. Through the point P draw the given section plane (VT), which is parallel to the XY line, in this case.
4. Then mark the points of intersection of the section plane with the different edges of the pyramid in the front view.
5. Project these points to their corresponding location, on the projections of their respective edges, in the top view. Then name these corner point as shown.
6. Join, systematically, all these points to obtain the boundary of the section in top view.
7. Finish the views, by drawing firm lines through the remaining visible edges and by drawing double chain lines through the projections of the cut portions of the edges.

PROBLEM 14.5. *A right circular cone, base diameter 50 mm and height 60 mm, lies on one of its elements in HP, such that its axis is parallel to VP. A section plane parallel to the HP and perpendicular to the VP cuts the cone, meeting the axis at a distance of 15 mm from the base. Draw the front view and sectional top view of the cut cone.*

SOLUTION: Refer *Fig. 14.5.*

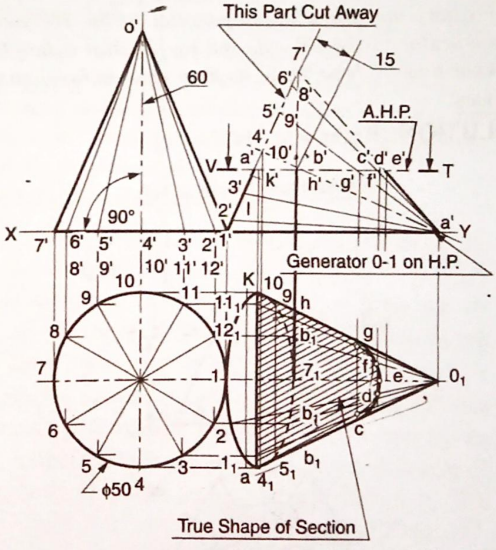

Fig. 14.5.

As already pointed out, major part of the problems on sections of solids comprises of the projections of the solids. Therefore, before attempting to solve problems on section of solids, the student must thoroughly learn to draw the projections of solids held in different positions.

When the cone lies on one of its generators on HP, its axis is inclined to the HP. Therefore, in the initial position, draw the projections of the cone assuming its axis to be perpendicular to the HP. Draw the top view first.

Unlike pyramids, there are no slant edges on the surface of the cone and we need some elements, to plot the intersections of which with the section plane in order to plot, in the two views, to be able to draw the boundary of the section obtained. To do so, divide the circle in the top view into 12 equal parts, as explained in chapter 1. Name the division points and join them, by thin lines, to the top view **o** of the vertex O. Project these division points to the base in the front view and join them all to **o′**.

Next change the position of the front view such that the side element **o′1′**, which is true length, lies on XY line. Project from it the corresponding top view. Mark a point along the axis in the front view 15 mm from base. Through this point draw VT parallel to the XY line to represent the section plane. The elements **o′4′**, **o′5′** up to **o′10′** are cut by the section plane line at **b′**, **c′**, **d′**, **e′**, **f′**, **g′**, and **h′**. Their corresponding top views are on the elements $o_1\ 4_1$, $o_1\ 5_1$ up to $o_1\ 10_1$ as **b**, **c**, **d**, **e**, **f**, **g**, and **h**. Further the base of the cone is cut at **a′** at the front and at **k′** at the rear of the base circle. Project these points, downwards to intersect the ellipse representing the base circle in top view at **a** at the front and k at the rear. Join **a** to **k** by a straight line and points **a**, **b**, **c**, **d**, **e**, **f**, **g**, **h** and **k** by a smooth curve, as shown.

The projections of the cut away part should be drawn by thin short double chain lines and the projections thus obtained, of the remaining cut cone, be made bold. Draw thin, uniformly spaced section lines in the sectioned area **abcdefghk**.

PROBLEM 14.6. *A right regular pentagonal prism, base edge 30 mm and height 70 mm, is held on HP on one of its base edges, such that its axis is parallel to VP and inclined to HP at 30°. An auxiliary horizontal plane cuts the prism, intersecting its axis at a distance of 17 mm from its top end. Draw its front view and sectional top view.*

SOLUTION: Refer *Fig. 14.6.* The procedure used is same as used for problem 4. The interpretation of the solution is left to the reader.

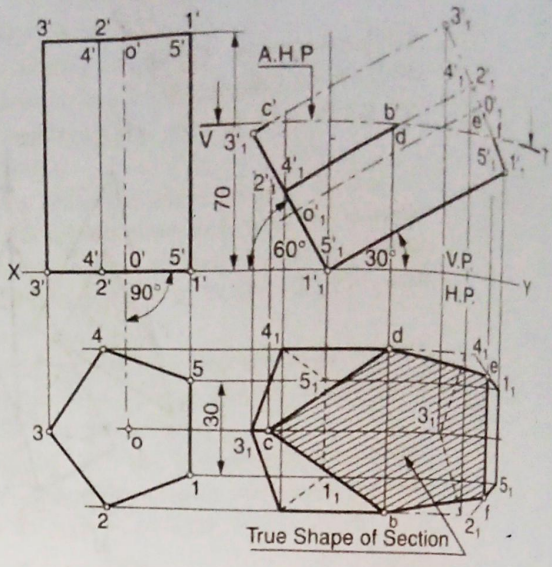

Fig. 14.6. First Angle Projection

PROBLEM 14.7. *A right circular cylinder, diameter of base 50 mm and height 80 mm, rests on its base rim such that its axis is inclined at 45° to the HP and is parallel to the VP. A section plane parallel to the HP cuts the axis at a distance of 50 mm from its base. Draw its front view and sectional top view.*

SOLUTION: Refer *Fig. 14.7.*

1. Draw the top and front views of the cylinder, assuming its axis to be perpendicular to the HP, in the initial stage.
2. Divide the base circle in top view into 12 equal parts and project these division points to the front view to obtain 12 elements in it.
3. Next change the position of the front view such that the axis (TL) makes an angle of 45° to the XY line.
4. Project from the points on the lower end face downwards, and from the points on the top view of the initial stage project horizontally, to obtain the top views of these 12 points at the corresponding intersections as 1_1, 2_1, up to 12_1. Draw horizontal lines through these points.
5. Next draw a cutting plane line VT, to represent the horizontal section plane at a distance of 50 mm from the base in the front view.
6. The section plane cuts the elements **1′1′**, **2′2′**, so on, at points **a′**, **b′**, and so on upto *l*. Project these points upwards to intersect the horizontal projectors drawn through points 1_1, 2_1 etc. At points **a**, **b**, **c**, up to *l* to locate the points on the boundary of the section in top view.

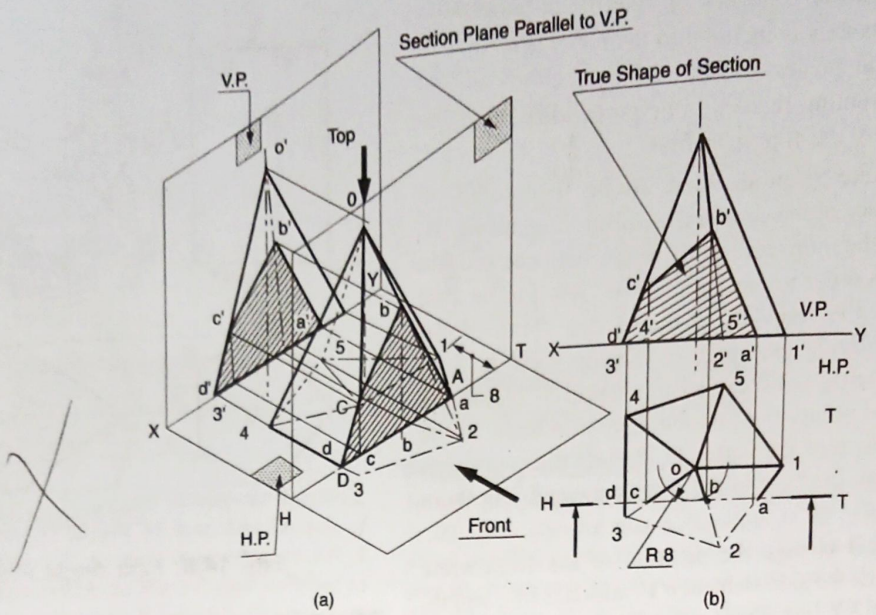

Fig. 14.8. First Angle Projection

edges $o_1 2_1$ and $o_1 3_1$ at **b** and **c**, respectively. Their projections on the corresponding projections of the edges in the front view, locate points **a′, b′, c′**, and **d′**, as shown. These points when joined by means of straight lines give the required section.

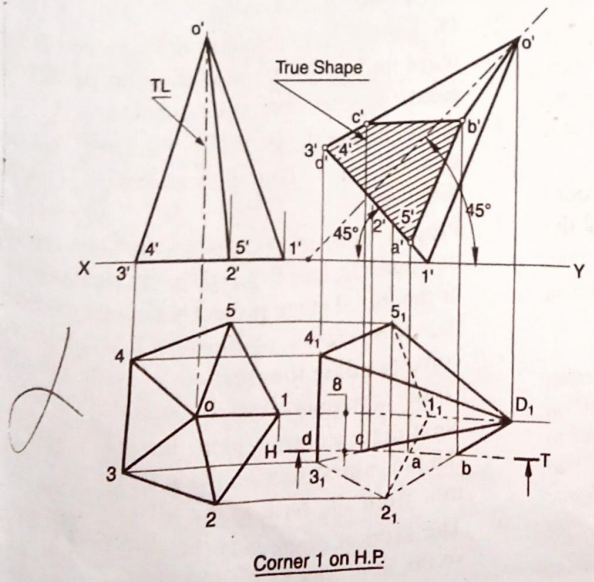

Fig. 14.9. First Angle Projection

4. Keeping the visibility of various edges in mind, finish the top view and sectional front view of the cut pyramid.
5. As the cutting plane line is parallel to the VP the projection of the section, **a′b′c′d′**, in front view is true shape and size.

PROBLEM 14.10. *A cube of 30 mm edge, rests on HP on one of its corners, with its body diagonal perpendicular to the HP. A section plane perpendicular to the HP and parallel to the VP cuts the cube and is 10 mm away from the body diagonal towards the observer. Draw its top and sectional views.*

SOLUTION: Refer *Fig. 14.10.*

1. Draw the projections of the cube, keeping the body diagonal C1 perpendicular to HP, in light lines.
2. As the section plane is parallel to VP it is represented by its trace HT in the top view, drawn at a perpendicular distance of 10 mm from the top view $\mathbf{c_1}$ of the vertical body diagonal in the final stage. The HT is parallel to the XY line.
3. Project the points of intersection of the HT with various edges in top view, to the corresponding front views of the edges in the front view of second stage.

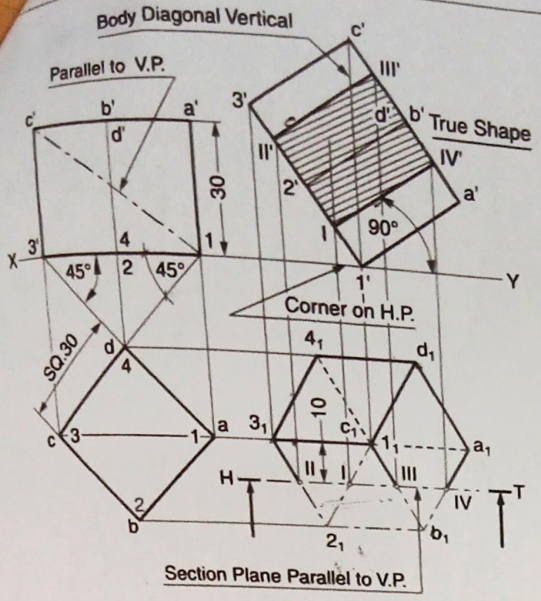

Fig. 14.10.

4. Fair out the projections of the cut cube, by bold lines, keeping in mind the visibility of various edges.
5. Join mutually the points on the section and draw section lines in it.

PROBLEM 14.11. *A right hexagonal prism, side of base 25 mm and length of axis 72 mm, lies on one of its rectangular faces in HP, with its axis inclined at 30° to VP. A vertical section plane parallel to the VP cuts the axis at a distance of 6 mm from the end face away from the VP. Draw its top view and sectional front view.*

SOLUTION: Refer *Fig. 14.11.*

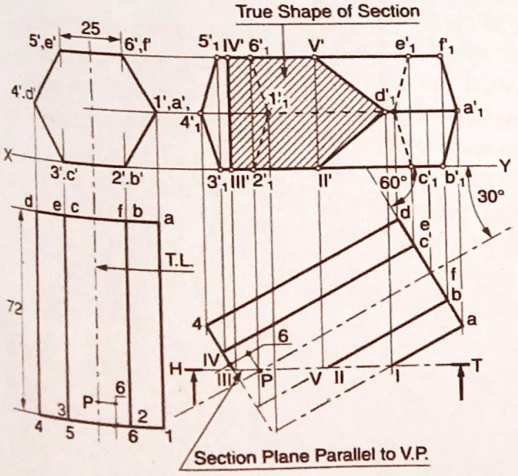

Fig. 14.11.

1. Draw the projections of the prism, in light lines, satisfying the given conditions and label the corner points as shown.
2. Draw the section plane HT, to represent the section plane in top view, parallel to XY line and passing through a point 6 mm along the axis, as shown.
3. Projects the points of intersection I, II, III, IV and V of the cutting plane line, with the various edges in top view, to their corresponding positions in front view as I′, II′, III′, IV′, and V′.
4. Leaving the projections of the cut away portion of the prism in light thin double chain lines, fair out all the other lines.
5. Join I′, II′, III′, IV′, and V′ mutually, by straight lines, to obtain the section and draw section lines in the area in section.

PROBLEM 14.12. *A right circular cone, diameter of base 54 mm and height 64 mm, lies on one of its elements in HP with its axis parallel to VP. A vertical section plane, parallel to the VP and 10 mm away from the axis, cuts the cone. Draw the top view and sectional front view of the cut cone.*

SOLUTION: Refer *Fig. 14.12.*

1. Draw the projections of the cone satisfying the given conditions, as shown.
2. Draw the cutting plane line HT, which is the horizontal trace of the section plane, at a distance of 10 mm and parallel to the axis in top view.
3. The cutting plane line HT cuts the ellipse for the base rim at **a** and **g**, and elements **o**2, **o**3, **o**4, **o**5 and **o**6 at points **b, c, d, e,** and **f** in the final top view.
4. Project the points **a** and **g** vertically upwards to points **a′** and **g′** lying on the projection of the base rim in front view. Also project points **b, c, d, e,** and **f** on the final front view of the corresponding elements **o′2′**, **o′3′** etc. As **b′, c′, d′, e′, f′**.
5. Join points **a′, b′, c′, d′, e′, f′,** and **g′** by a smooth curve, as the cone is a solid of revolution. Draw section lines in this sectioned area.
6. Fair out the view for the cut cone (leaving the projections for cut away portion as thin double chain lines).