UNIT 4 ORTHOGRAPHIC PROJECTIONS-II

Structure

4.1 INTRODUCTION

After having learnt in Unit 3 about the theory of projection of points, lines and planes, the next important is the projection of solids which have three dimensions: length, breadth and thickness.

In engineering practice, we often come across with solids bounded by simple or complex geometric surface. To represent a solid in orthographic projection will depend upon the type of solid and its orientation with respect to the principal planes of projection.

Objectives

After studying this unit, you should be able to

- understand various types of solids generally used in engineering drawings,

- draw orthographic projections of various solids in simple position as well as when their axis is inclined to reference planes,
- draw orthographic projections of various solids when a portion of the solid is cut by a section plane, and
- draw auxiliary views of solids on other planes known as auxiliary planes.

4.2 TYPES OF SOLID

A solid is a three-dimensional object having length, breadth and thickness. It is completely bounded by surfaces which may be plane or curved and accordingly solids may be classified as polyhedra and solids of revolution.

4.2.1 Polyhedra

A polyhedra is defined as a solid bounded by plane surfaces called faces. There are two types of polyhedra which are

(a) Regular, and

(b) Irregular or oblique.

Regular Polyhedra or Regular Solid

A regular polyhedron is a solid bounded by faces which are equal and regular, as shown in Figure 4.1.

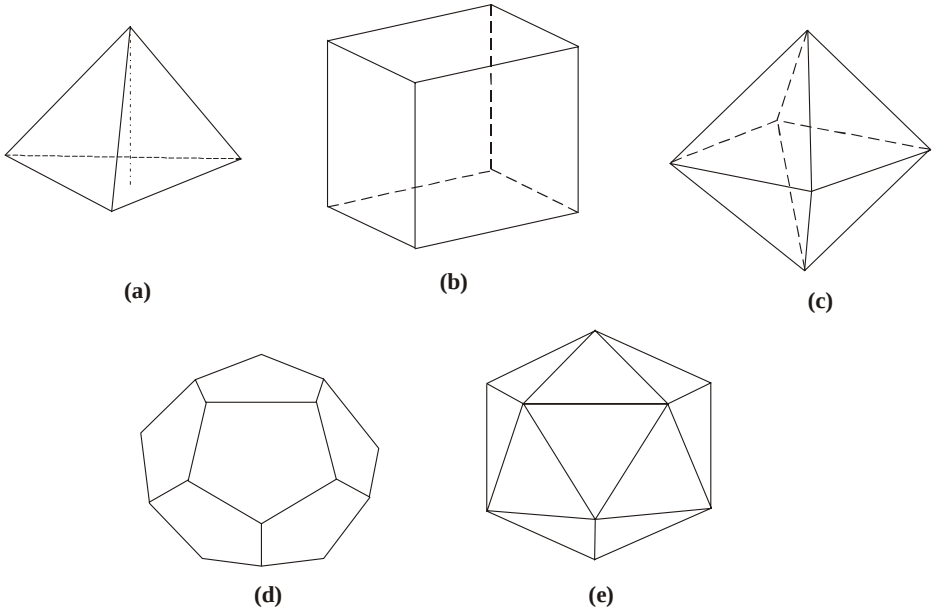


Figure 4.1

Tetrahedron

It has four equal faces, each an equilateral triangle (Figure 4.1(a)).

Cube or Hexahedron

It has six equal faces, each a square as in Figure 4.1(b).

Octahedron

It has eight equal faces, each an equilateral triangle (Figure 4.1(c)).

Dodecahedron

It has twelve equal faces, each a regular pentagon as in Figure 4.1(d).

Isosahedron

It has twenty equal faces, each an equilateral triangle (Figure 4.1(e)).

Prism

A prism is a polyhedron having two equal ends or bases parallel to each other. These two bases are joined by faces which are rectangles. The line joining the centres of the base is called the axis of the prism.

A right and regular prism has its axis perpendicular to the bases and all its faces are rectangles. According to the shape of base the prism may be triangular (Figure 4.2(a)), square (Figure 4.2(b)), pentagonal (Figure 4.2(c)), or hexagonal (Figure 4.2(d)).

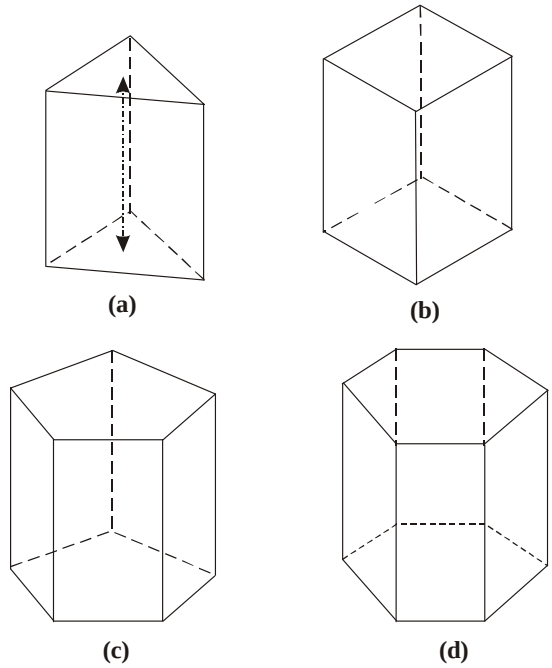


Figure 4.2

Pyramid

A pyramid is a polyhedraon having one base and a number of isosceles triangles as faces meeting at a point called the vertex or apex. The line joining the centre of the base and the apex is called the axis of the solid.

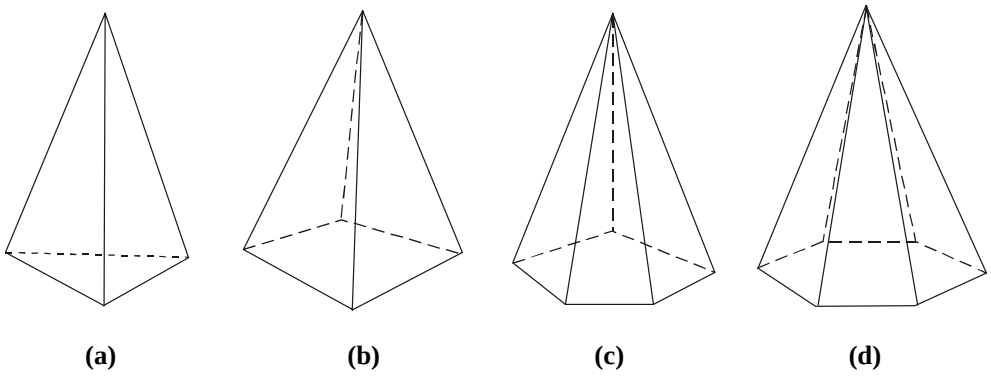
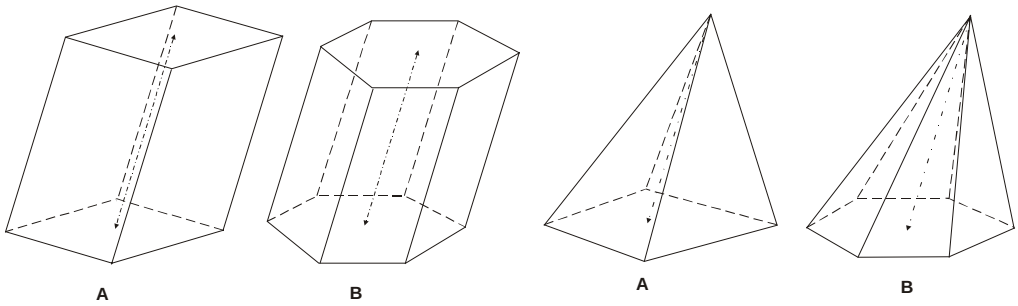


Figure 4.3

A right and regular pyramid has its axis perpendicular to base and its faces are all equal isosceles triangles. According to the shape of the base the pyramid may be triangular pyramid (Figure 4.3(a)), square pyramid (Figure 4.3(b)), pentagonal pyramid (Figure 4.3(c)) or hexagonal (Figure 4.3(d)).

Irregular or Oblique Polyhedra

In case of irregular polyhedra or solid, the axis is inclined to the base. The faces of an oblique prism (Figure 4.4(a)) are parallelogram and faces of pyramids (Figure 4.4(b)) are triangles which are not similar. The bases of oblique prisms are parallel, equal and similar.



(a) Oblique Prisms **(b) Oblique Pyramids**

Figure 4.4

4.2.2 Solids of Revolution

Solids of revolution are obtained or generated by rotating a plane figure about one of its edges. Solids of revolution may also be classified as :

(a) Regular, and

(b) Oblique.

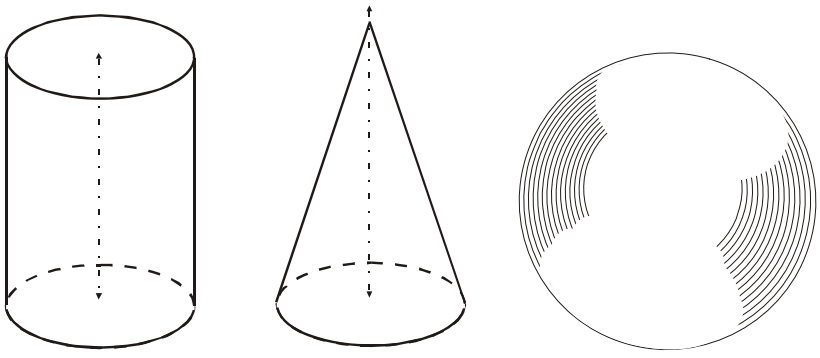
Regular Solids of Revolution

Cylinder

A cylinder is generated by rotating a rectangle about one of its edges as in Figure 4.5(a). A cylinder has two equal circular bases. The line joining the centres of the bases is the axis, and is perpendicular to the bases.

Cone

A cone is generated by rotating a right angle triangle about one of its perpendicular sides. The lateral surface is connected with circular base (Figure 4.5(b)). Line joining apex and centre of base is the axis and it is perpendicular to base.



(a) Cylinder **(b) Cone** **(c) Sphere**

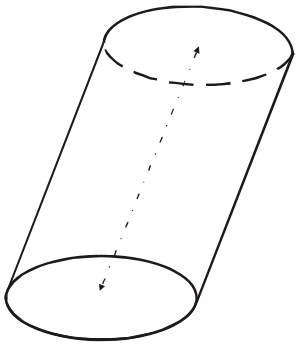
Figure 4.5

Sphere

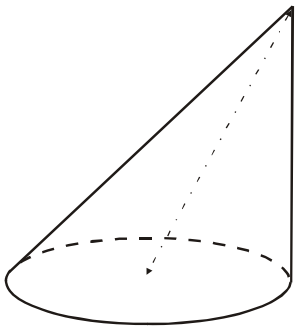
A sphere is a solid of revolution generated by rotating a semi-circle about its diameter (Figure 4.5(c)). The mid-point of the diameter is the centre of the sphere.

Oblique Solids

Oblique cylinders and cones have their axes inclined to their bases as shown in Figures 4.6(a) and (b).



(a) Oblique Cylinder



(b) Oblique Cone

Figure 4.6

4.3 ORTHOGRAPHIC PROJECTIONS OF SOLID

Here in this unit, mostly right and regular solids are dealt with. Hence, when a solid is referred without any description it should be understood as being right and regular.

The position of a solid in space may be specified by the location of either the axis, edges or surfaces with the principal planes of projection. The following are some of the positions of solids for which orthographic projections are explained.

(a) Axis of the solid perpendicular to one of the principal plane.

(b) Axis of the solid parallel to both the principal plane.

(c) Axis inclined to one of the principal planes and parallel to the other.

(d) Axis inclined to both the principal planes.

4.3.1 General Guidelines for Drawing Projections of Solid

(a) If nothing is specified about a solid it should be understood as being right and regular. For example, for a “cone”, means a right and regular cone.

(b) When an axis is perpendicular to one reference plane, it is parallel to the other.

(c) When an axis of the solid is perpendicular to a plane, its base will be parallel to that plane.

(d) Projection of a solid on a plane to which its axis is perpendicular will show the true shape and size of its base.

(e) When an axis is perpendicular to the HP, the top view should be drawn first and the front view should be projected from it.

(f) When an axis is perpendicular to VP, the front view should be drawn first and the top view should be projected from it.

(g) If a solid has an edge of its base parallel to the HP or in HP, that edge should be kept perpendicular to the VP. If the edge of the base is parallel to the VP or in the VP that edge should be kept perpendicular to the HP.

(h) If a solid has a corner of its base on the HP, the sides of the base containing that corner should be kept equally inclined to the VP. If the corner of the base is in the VP, the sides of the base containing that corner should be kept equally inclined to the HP.

4.4 ORTHOGRAPHIC PROJECTION OF SOLID WHEN THE AXIS IS PERPENDICULAR TO ONE OF THE PRINCIPAL PLANES AND PARALLEL TO THE OTHER

A solid in simple position may have its axis perpendicular to one reference plane and parallel to other reference plane. The two cases described here are when the axis is perpendicular to HP or VP.

4.4.1 Axis Perpendicular to the HP

For drawing orthographic projection of various solids such as prisms, pyramids, cones and cylinders the general procedure is as follows :

Step-I

First draw the plan (in which base represent the true shape) considering guidelines as per Section 4.3.1.

Step-II

Number the various corners of the base for prisms and pyramids and for cylinder and cone divide the circle in even number of parts such as 8, 12 or 16 and mark the points on circumference of circle (like *a*, *b*, *c*, *d* or 1, 2, 3, 4 etc.).

Step-III

Draw the elevation with the help of known length of axis and projecting various points from plan of the solid (Mark a' b' c' d' or $1'$ $2'$ $3'$ $4'$ … etc.)

Projections of a cylinder (Figure 4.7), a cone (Figure 4.8), a cube (Figure 4.9), a triangular prism (Figure 4.10) and a pentagonal pyramid (Figure 4.11) are drawn as per above procedure.

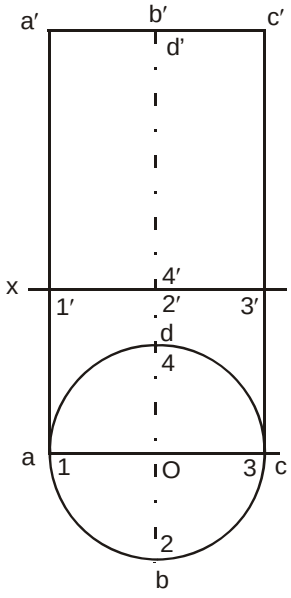


Figure 4.7

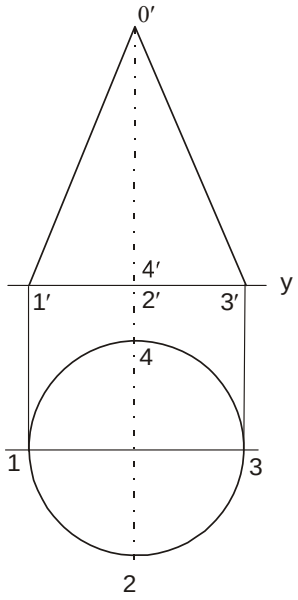


Figure 4.8

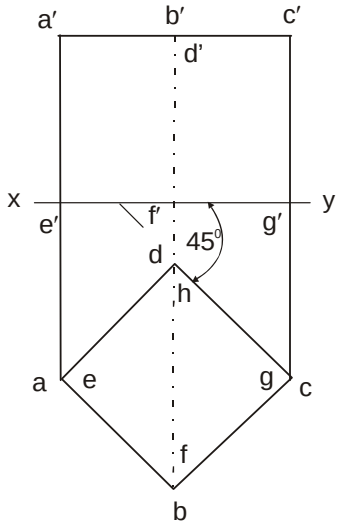


Figure 4.9

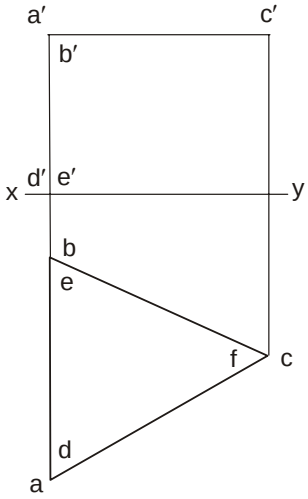


Figure 4.10

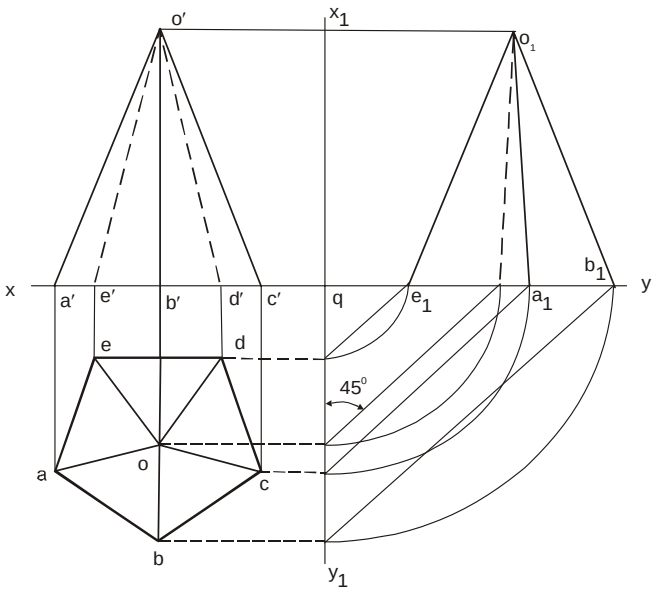


Figure 4.11

4.4.2 Axis Perpendicular to the VP

For drawing orthographic projections of various solid such as prisms, pyramids, cylinders and cones, general procedure is as follows:

Step I

First draw the elevation (in which base represent the true shape) considering guidelines as per Section 4.3.1.

Step II

Numbers the various corners of the base for prisms and pyramids and for cone and cylinder divide the base circle in even number of parts such as 8, 12 or 16 and mark the points on circumference of the circle (*a′ b′ c′ d′* or 1′ 2′ 3′ 4′ etc.).

Step III

Draw the plan with the help of known length of axis and projecting various points from elevation of the solid (Mark *a*, *b*, *c*, *d* or 1, 2, 3, 4, … etc.).

Projection of a cylinder (Figure 4.12), a cone (Figure 4.13), a hexagonal prism (Figure 4.14) and a pentagonal pyramid (Figure 4.15) are drawn as per above procedure.

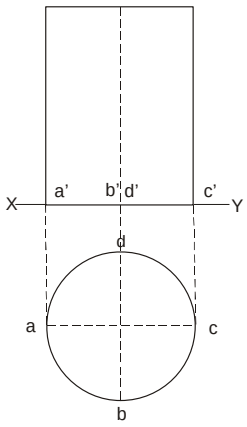


Figure 4.12

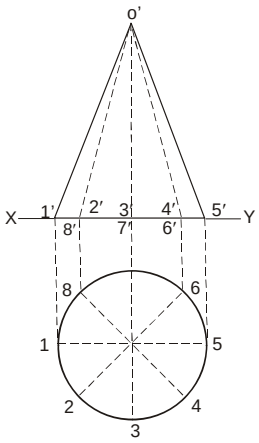


Figure 4.13

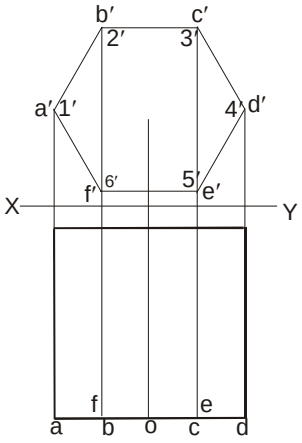


Figure 4.14

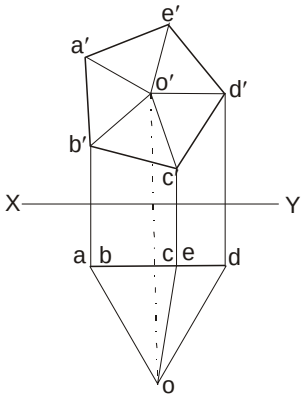


Figure 4.15

Example 4.1

A square prism, side of base 40 mm and axis 60 mm long is resting on the HP on its base with one edge inclined at 30^o to the VP. Draw its projections.

Solution

Construction procedure is as follows :

(a) Draw a line at 30^o to *xy* and draw the plan which is a square of 40 mm side and mark corners as *a*, *b*, *c* and *d*.

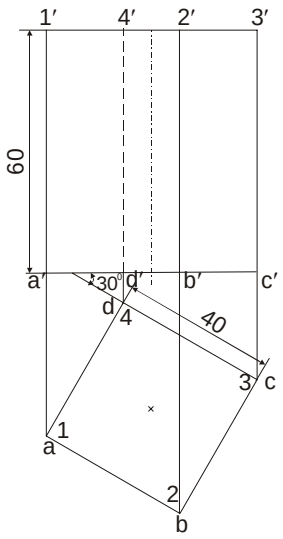


Figure 4.16

(b) Project the point *a*, *b*, *c* and *d* on the reference line *xy* meeting it at *a*′, *b*′, *c*′ and *d*′.

(c) Draw the axis and mark 60 mm from *xy* along the axis (height of prism).

(d) Draw a horizontal line parallel to *xy* and 60 mm from it.

(e) Draw projectors from *a*, *b*, *c* and *d* and mark 1′, 2′, 3′ and 4′ on it.

(f) Join 1′ *a*′, 2′ *b*′, 3′ *c*′ and 4′ *d*′ (dotted line) to complete the elevation.

(g) Darken the visual edges in the elevation.

Example 4.2

A tetrahedron of side 60 mm has its base parallel to the VP, with an edge of the base inclined at 45^{o} to the HP. The corner contained by that edge is on the HP. Draw its projections.

Figure 4.17

Solution

Construction procedure is as follows :

(a) Draw a line at 45^{o} to *xy* in VP, and complete the elevation *a*′ *b*′ *c*′ (with point *c*′ in *xy*). Mark centre ′.

(b) Draw line *abc* parallel to *xy* representing the base in elevation.

(c) To mark point *O* in plan, rotate *o*′ *a*′ in elevation about *o*′ to *o*′ a'_1 parallel to *xy*.

(d) Locate a_1 along extension line of *abc* and mark *o* (a_1 *o* equal to 60 mm) along axis.

(e) Join oa_1, ob_1, oc_1 (dotted line) to complete the plan.

4.5 ORTHOGRAPHIC PROJECTIONS OF SOLID WHEN THE AXIS IS PARALLEL TO BOTH THE HP AND VP

When the axis is parallel to both the HP and VP, neither the top view nor the front view will show the actual shape of the base. In this case, the projection of the solid on an auxiliary plane perpendicular to both the plane, i.e. the side view must be drawn first. The front view and the top view are then projected from the side view. In Example 4.3, above procedure is explained for drawing orthographic projections of a prism.

Example 4.3

A triangular prism base 40 mm side and height 65 mm is resting on the ground on one of its, rectangular faces with the axis parallel to both HP and VP. Draw its projection.

Solution

(a) Draw an equilateral triangle $a_1\ b_1\ c_1$ representing the side view with one side $a_1\ c_1$ in xy.

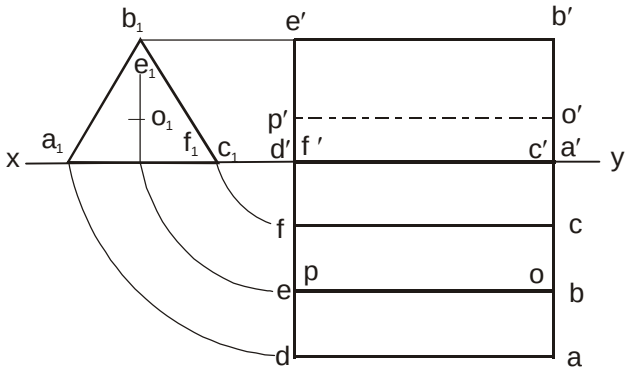


Figure 4.18

(b) Project the front view horizontally from this triangle where $a'\ d'$ is the height of prism. Locate $d'\ e'\ f'$ and complete the front view.

(c) Project down the top view from the front view and the side view and mark *abc* and *def* and complete the plan.

4.6 ORTHOGRAPHIC PROJECTIONS OF SOLID WHEN THE AXIS IS INCLINED TO ONE OF THE PRINCIPAL PLANES AND PARALLEL TO THE OTHER PRINCIPAL PLANE

When the axis of a solid is inclined to any principal plane, the final projections are obtained in two stages. In first stage, the axis of the solid is assumed to be perpendicular to the principal plane, to which it is actually inclined and the views are drawn. The final projections may be obtained by one of the following two methods.

(a) Alteration of position method.

(b) Alteration of reference line.

In method (a), the position of one of the view is altered to suit the given condition and the other view is projected from it.

In method (b), instead of reconstructing one of the views as mentioned above, an auxiliary plane is imagined, satisfying the given condition and the other view is projected on it. This is advantageous compared to method (a) as this avoids redrawing of one of the views, specially when the solid has curved surfaces or too many edges and corners.

4.6.1 Axis Inclined to HP and Parallel to the VP

To explain the procedure, Example 4.4 is given for alteration of position method and Example 4.5 is given for alteration of reference line method while in Example 4.6 same problem is solved by these two methods.

Example 4.4

Draw the projection of a cylinder of 60 mm diameter and 70 mm long which is resting on a point on the HP. The axis is inclined at 60^o to the HP and parallel to VP.

Solution

(a) Draw the elevation and plan assuming the axis to be perpendicular to HP and parallel to VP.

(b) Divide base of the cylinder in plan into say 12 equal parts.

Figure 4.19

(c) Mark 1, 2, … 12 in plan and 1′, 2′,… 12′ in elevation.

(d) Redraw the elevation such that the axis makes an angle of 60^o with a point of bottom base in *xy*.

(e) Project final plan by projection various points from first plan and inclined elevation.

Example 4.5

A right regular hexagonal pyramid 80 mm in height and side of base 35 mm, having an edge of the base in HP and the face containing that edge is inclined at 47^o to HP. Draw its projection.

Solution

(a) Draw the hexagonal plan 1, 2, 3, 4, 5, 6 with side 35 mm and one side of base 1, 6 is perpendicular to VP.

(b) Complete elevation with base in HP and axis of the pyramid perpendicular to HP and parallel to VP.

Figure 4.20

(c) To obtain the final plan by alternation of reference line method draw another reference line $X_1\ Y_1$ passing through point $1'$ and $6'$ at an angle of 47^o with $1'\ O'$ (slant edge of pyramid).

[**Note :** X_1Y_1 is intersection of VP and auxiliary HP on which plan is to be drawn.]

(d) Draw projections from various points in elevation which are perpendicular lines to $X_1\ Y_1$.

(e) Take the distance of points 1, 2, 3, 4, 5, 6 and O from XY and mark 1_1, 2_1, 3_1, 4_1, 5_1, 6_1 and O_1 on respective projectors which are perpendicular to $X_1\ Y_1$ (For example to locate point 1_1, distance $1'\ 1_1$ is equal to $1'\ 1$).

(f) Draw hexagonal base by joining $1_1\ 2_1\ 3_1\ 4_1\ 5_1\ 6_1$ (visible) and join O_11_1, O_12_1, O_16_1, O_15_1 by dark line (visible) and O_13_1 and O_14_1 by dotted line (not visible) and complete the plan.

Example 4.6

Draw the projections of a pentagonal prism edge of the base 50 mm long and height 90 mm, the axis of which is inclined at 70^o with HP and parallel to the VP with an edge of the base in HP.

Solution

(a) Draw the projection of the solid assuming that the axis is perpendicular to the HP and parallel to VP with one of the edge of the base (*a*, *b*) perpendicular to VP. Figure 4.21(i) shows the views in this condition.

Figure 4.21

(b) Redraw the elevation such that its axis makes an angle $\theta = 70^o$ with the *xy*.

(c) Project the plan (ii) from projecting various points from initial plan (i) and inclined elevation.

(d) Figure 4.21(ii) shows the desired elevations and plan by alteration of position method.

(e) Figure 4.21(iii) shows the desired plan by alteration of reference line method.

SAQ 1

(a) To draw the plan and elevation of a cube of 55 mm edge when a solid diagonal of the solid is vertical using

(i) Alteration of position of solid, and (ii) Alteration of ground line.

[**Note :** The solid diagonal is the imaginary line passing from one corner of the cube to the directly opposite corner.]

(b) A hexagonal pyramid base 25 mm side and axis 50 mm long has an edge of its base on the ground. Its axis is inclined at 30^o to the HP and parallel to the VP Draw its projections.

(c) Draw the projection of a cone, base 75 mm diameter and axis 100 mm long, lying on the ground on one of its generators with the axis parallel to the VP.

4.6.2 Axis Inclined to VP and Parallel to HP

When the axis of the solid is perpendicular to VP and parallel to HP the general procedure is same for various solids and explained here in Example 4.7 for a pyramid.

Example 4.7

Draw the projections of a pentagonal pyramid the axis of which is inclined at 30^o to VP and parallel to the HP with a corner of the base in VP. Pyramid is having edge of base 60 mm and height 90 mm.

Procedure

(a) Draw the reference line *XY* and draw the pentagon in elevation with one side perpendicular to *XY*. Mark corners a' b' c' d' e' and centre o'.

(b) Draw the plan considering axis is perpendicular to VP and parallel to HP with base in VP. For this project a' b' c' d' e' on *XY* and obtain point *a*, *b*, *c*, *d*, *e*. Take length of axis 90 mm and mark point *o*, and complete the plan as shown in Figure 4.22(a).

Figure 4.22

(c) Revolve the plan along point *d*, such that axis make an angle of $\phi = 30^o$ with the *XY* and reconstruct the plan.

(d) Project points from elevation and reconstructed plan to obtain the desired elevation. Join o_1' with a_1', b_1', c_1', and e_1' by dark line (visible) and o_1' with d_1' by dotted line (not visible). Triangular face o_1' d_1' c_1' and o_1' d_1' e_1' is not visible in front view. Draw d_1' c_1' and d_1' e_1' dotted line to obtain the desired projection as shown in Figure 4.22(b).

(e) To obtain the desired projection by auxiliary plane method draw X_1 Y_1 through *d* and at 30^o to VP. Draw the projectors through *a*, *b*, *c*, *d*, *e* and *o*, perpendicular to X_1 Y_1 and transfer distances from elevation and mark o_1', a_1', b_1', c_1', d_1', e_1' to obtain the desired elevation on auxiliary plane.

Figure 4.22(c) is the desired projection.

SAQ 2

(a) Draw the projections of a pentagonal prism base 25 mm side and axis 50 mm long, resting on one of its rectangular faces on the ground, with the axis inclined at 45^o to VP.

(b) Draw the projections of a cylinder 75 mm diameter and 100 mm long, lying on the HP, with its axis inclined at 30^o to the VP and parallel to the HP.

4.7 ORTHOGRAPHIC PROJECTIONS OF SOLID WHEN THE AXIS IS INCLINED TO BOTH THE PRINCIPAL PLANES

The projections of a solid with its axis inclined to both the plane HP and VP are drawn in three stages.

Stage-I

Assume the axis is perpendicular to one of the planes (HP or VP) and draw the projections.

Stage-II

Redraw one of the views by making the axis inclined to one of the planes and project the other view from it.

Stage-III

Redraw one of the views obtained in Stage II, satisfying the remaining condition and project the other view from it.

Stages II and III may also be drawn by the use of the auxiliary plane method.

Example 4.8

Draw the projection of a hexagonal prism edge of base 50 mm and 100 mm in height with axis inclined at 60^o to the HP and one edge of base is in HP and inclined at 60^o with the VP.

Solution

Stage-I

Draw the projection of the hexagonal prism assuming that it is resting with base in HP with one edge of base perpendicular to the VP and axis perpendicular to HP and parallel to the VP.

Stage-II

Redraw the elevation such that its axis makes the angle $\theta = 60^o$ with *xy* with one edge of base *de* remains in HP.

Draw the plan by projecting points from initial plan and inclined elevation.

(a)

(b)

Figure 4.23

Stage-III

Redraw the plan such that the edge $a_1\ b_1$ makes the angle $\phi = 60^o$ with *xy*.

Draw the final elevation by projecting points from inclined elevation and final plan.

The projections obtained by the Stage III are the required projections.

Figure 4.23(b) shows the construction in which desired plan and elevation are drawn by making use of auxiliary projections.

Here after Stage-I, Stage-II is completely eliminated. Final plan is drawn by taking auxiliary projection on $X_1\ Y_1$ inclined at $\theta = 60^o$ with

the axis and final elevation is drawn by taking auxiliary projection on $X_2\ Y_2$ which is inclined at $\phi = 60^o$ with edge of base $a_1\ b_1$.

SAQ 3

(a) A pentagonal pyramid base 50 mm side and axis 100 mm long has one of its triangular faces in the VP and the edge of the base contained by that face makes an angle of 30^o with the HP. Draw its projections.

(b) A square prism base 40 mm side and height 65 mm has its axis inclined at 45^o to the ground and has an edge on its base on the ground and inclined at 30^o to the VP. Draw its projections.

(c) Draw the projection of a cone, base 45 mm diameter and axis 50 mm long, when it is resting on the ground on a point on its base circle with the axis making an angle of 30^o with the HP and 45^o with the VP.

(d) Draw the projections of a hexagonal pyramid side of base 35 mm and height 60 mm standing on an edge of its base in HP, the resting edge making an angle of 45^o to VP. The slant face containing this edge makes an angle of 60^o to HP.

(e) A hexagonal pyramid of base 25 mm side and 60 mm high is resting on a triangular face on the ground with its axis parallel to the VP. A vertical section plane whose HT bisects the axis is inclined at 30^o to the VP.

Draw the sectional front view and true shape of the section, retaining the portion of the solid containing the apex.

4.8 SECTIONS OF SOLID

The orthographic projections of an object may not give the idea about its interior details. In order to achieve this, it is customary to imagine that the object has been cut through or sectioned by planes. The part of the object between the cutting plane and the observer is assumed to be removed and the view is then shown in section.

(a) The imaginary plane is called a *section plane* or a *cutting plane*.

(b) The surface produced by cutting the object by the section plane is called the *section*, and it is indicated by thin section line uniformly spaced and inclined at 45^o.

(c) The projection of the section along with the remaining portion of the object is called a *section view*.

4.8.1 Positions of Section Plane

The shape of the section obtained will depend upon the orientation of the solid and the section plane with respect to the principal planes of projection.

The following are some of the positions of the section planes :

(a) Section plane parallel to the HP and perpendicular to the VP.

(b) Section plane parallel to the VP and perpendicular to the HP.

(c) Section plane inclined to the HP and perpendicular to the VP.

(d) Section plane inclined to the VP and perpendicular to the HP.

(e) Section plane perpendicular to both the HP and VP.

(f) Section plane inclined to both the HP and VP.

4.8.2 Rules for Making the Section Plane and Views

Section planes are generally perpendicular planes. It is important to remember the following :

(a) Section planes are usually described by their traces.

(b) Projection of a section plane on the plane to which it is perpendicular is a straight line coinciding with the trace of the section plane on it.

(c) When the section plane is parallel to the HP and perpendicular to the VP, draw a line VT in the front view to represent the section plane.

(d) When the section plane is parallel to the VP and perpendicular to the HP, draw a line HT in the top view to represent the section plane.

(e) When the section plane is inclined to the HP and perpendicular to the VP, draw a line VT in the front view to represent the section plane.

(f) When the section plane is inclined to the VP and perpendicular to the HP, draw a line HT in the top view to represent the section.

(g) When the section plane is perpendicular to both HP and VP, draw a line VT in front view and a line HT in the top view to represent the section (section will be visible in side view).

(h) When the section plane is inclined to both HP and VP, draw a line (trace on end plane) in the end view to represent the section plane.

4.8.3 Apparent and True Shape of Section

When a solid is cut by the section plane, the section on the reference plan to which it is perpendicular will be a straight line. Its projection on the other plane to which it is inclined is called *apparent section.*

Apparent section is drawn by projecting on the other plane, the points at which the trace of the section plane intersects the edges or generators of the solid and drawing line joining these points in proper sequence.

The projection of the section on a plane parallel to the section plane will represent the true shape of the section.

4.8.4 Methods of Drawing True Shape of Section

(a) When the section plane is parallel to the HP, the true shape of the section will be same as section in top view.

(b) When the section plane is parallel to the VP, the true shape will be same as section in front view.

(c) When the section plane is inclined, the section has to be projected on an auxiliary plane parallel to the section plane, to obtain its true shape.

(d) When the section plane is perpendicular to both the reference planes, the section in side view will show the true shape of section.

4.8.5 Section of Polyhedra

When a section plane passes through any polyhedron, the intersection of the section plane with the surfaces of the solid consist of number of straight lines. Hence, the sectioned portion in a projected view is a plane figure bounded by straight line.

4.8.6 Section of Solids of Revolution

When the section plane passes through the lateral surface, the intersection is a smooth curve. If the section plane passes through the base of the cylinder or cone that part of the boundary will be a straight line.

Example 4.9

Section of various polyhedron are explained when they are cut by various position of section plane such as

(a) Section plane parallel to the HP and perpendicular to VP.

Figure 4.24 shows the front view and sectional top view of a triangular prism when it is lying on the ground on one of its rectangular faces with its axis inclined to the VP and it is cut by a horizontal section plane.

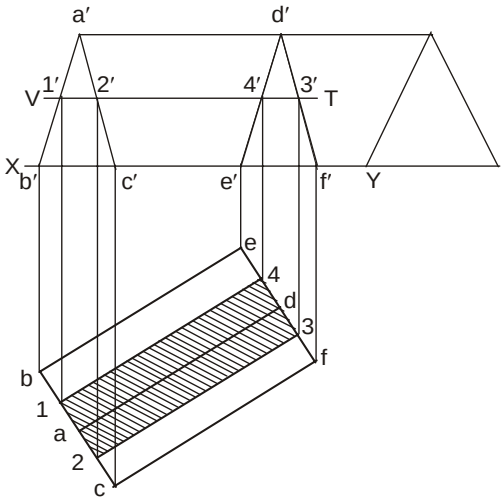


Figure 4.24 **Figure 4.25**

(b) Section plane parallel to the VP and perpendicular to HP.

Figure 4.25 shows the sectional front view and top view of a cube resting on the ground on one of its faces with a vertical face inclined to VP and cut by a section plane parallel to the VP.

(c) Section plane inclined to HP and perpendicular to the VP.

Figure 4.26 shows the front view, sectional top view, sectional side view and true shape of the section, of a square pyramid, has its base on the ground and all the edges of the base are equally inclined to the VP, and is cut by a section plane inclined to the HP and bisecting the axis.

Figure 4.26

(d) Section plane inclined to the VP and perpendicular to the HP.

Figure 4.27 shows the sectional front view, top view and true shape of the section of a cube resting on the ground on one of its faces with a vertical face inclined to the VP and is cut by a section plane inclined to the VP and perpendicular to the HP.

Figure 4.27

(e) Section plane perpendicular to both HP and VP.

Figure 4.28 shows top view, front view and sectional side view of a hexagonal pyramid resting on the HP on its base with a side of base parallel to VP is cut by a section plane perpendicular to both HP and VP.

Figure 4.28

Example 4.10

Section of solids of revolution are explained when they are cut by the various position of section plane such as

(a) Section plane parallel to the HP and perpendicular to VP.

Figure 4.29 shows the elevation and sectional plan of a cone resting on its base in HP and cut by a section plane parallel to the HP and perpendicular to VP.

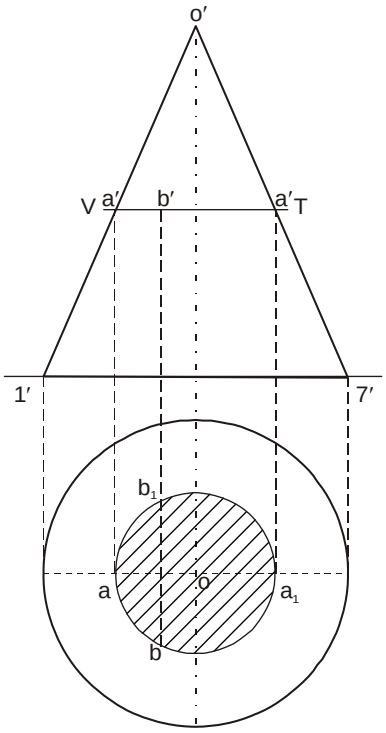


Figure 4.29

(b) Section plane parallel to VP and perpendicular to the HP.

Figure 4.30 shows the sectional elevation and plan of a cone resting on its base in HP and cut by a section plane parallel to the VP and perpendicular to HP.

Figure 4.30

(c) Sectional plane inclined to HP and perpendicular to the VP.

Figure 4.31 shows the front view, sectional top view, sectional side view and true shape of the section of a cylinder resting on its base in HP, and cut by a section plane perpendicular to VP and inclined to the HP and intersecting the axis.

Figure 4.31

(d) Section plane inclined to VP and perpendicular to the HP.

Figure 4.32 shows the sectional elevation, plan and true shape of the section of a cone resting with its base in HP and is cut by a section plane perpendicular to HP and inclined to VP and is away from the axis.

Figure 4.32

(e) Section plane perpendicular to both HP and VP.

Figure 4.33 shows the elevation, plan and sectional side view of a cone, resting on the ground on its base and cut by a section plane perpendicular to both HP and VP and away from the axis (above projections are obtained by the circle method, i.e. width of the section at any point say c' will be equal to cc_1).

Figure 4.33

SAQ 4

(a) A pentagonal prism edge of base 25 mm and axis 60 mm long is resting on one of its faces on the HP. The axis of the prism is parallel to both the planes. It is cut by a section plane, inclined at 45^o to the HP and passing through the axis 10 mm from one base. Draw section elevation and sectional end view.

(b) A cone base 75 mm and axis 80 mm long is resting on its base on the ground. It is cut by a section plane perpendicular to the VP, inclined at 45^o to the HP and cutting the axis at a point 35 mm from the apex. Draw its front view, sectional top view, sectional side view and true shape of the section.

SAQ 5

(a) A sphere of 50 mm diameter is cut by a section plane perpendicular to the VP, inclined at 45^o to the HP and at a distance of 10 mm from the centre. Draw the sectional top view and the true shape of the section.

(b) A cone base 60 mm dia and axis 60 mm long is lying on the ground on one of its generators with the axis parallel to the VP. A vertical section plane parallel to the end generator cuts the cone bisecting the axis and removing a portion containing the apex. Draw its sectional front view, and true shape of the section.

4.9 SUMMARY

(a) Solids have three dimensions – length, breadth and thickness. Solids are classified in two broad categories as polyhedra and solids of revolutions.

(b) In this unit, commonly used solids such as prisms, pyramids, cylinder, cone and sphere are considered to explain the concept of projection and section of solids.

(c) To draw orthographic projections of solids that is plan, elevation and end view, the position of the solid with respect to reference plane must be specified.

The various cases considered here are :

(a) When the axis of the solid is perpendicular to one reference plane and parallel to other.

(b) When the axis of the solid is parallel to both the reference planes.

(c) When the axis of the solid is perpendicular to one reference plane and inclined with other reference plane.

(d) When the axis of the solid is inclined to both the reference planes.

When the axis of the solid is inclined to both the plane, to draw the orthographic projections two methods are generally used, they are :

(a) Alteration of position method, and

(b) Alteration of reference line method.

Alteration of reference takes less time to represent orthographic views.

In this unit, orthographic projection of various solids in cut position is also explained. The following cases are explained:

(a) When the solid is cut by a cutting plane parallel to one plane and perpendicular to other.

(b) When the solid is cut by a cutting plane perpendicular to both the planes.

(c) When the solid is cut by a cutting plane perpendicular to one reference plane and inclined to other.

True shape of the section is obtained on a plane which is parallel to the cutting plane.

Projection of various solids such as cone, cylinder, prisms, pyramids and sphere are explained with the help of suitable examples in which various orientations of solids as well as various orientations or positions of the cutting plane is considered and orthographic projections are drawn.

4.10 ANSWERS TO SAQs

SAQ 1

(a)

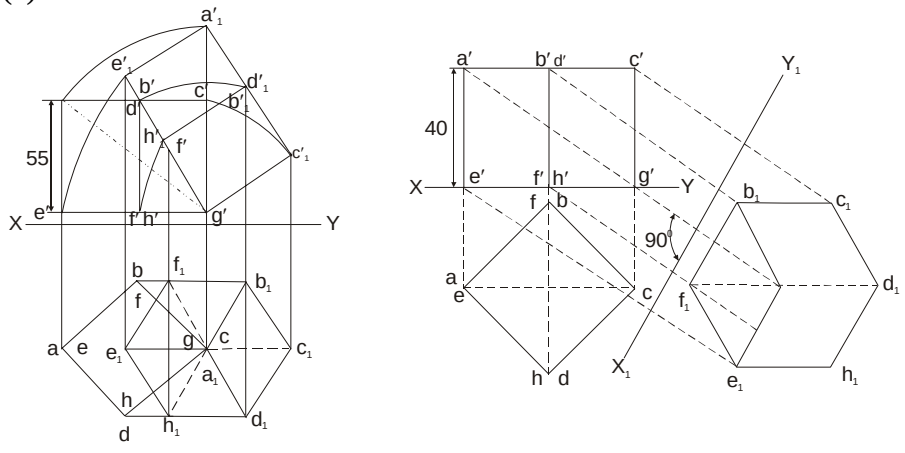


Figure 4.34

(b)

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

Figure 4.35

(c)

Figure 4.36

SAQ 2

(a)

Figure 4.37

(b)

Figure 4.38

SAQ 3

(a)

Figure 4.39

(b)

Method I : Alteration of Position Method

Method II : Alteration of Reference Line

Figure 4.40

(c)

Figure 4.41

(d)

Figure 4.42

(e)

Figure 4.43

SAQ 4

(a)

Figure 4.44

(b)

Figure 4.45

SAQ 5

(a) **Hint**

When a sphere is cut by a plane, the true shape of the section is always a circle.

In Figure 4.46, the sphere is cut by $a'g'$ which is diameter of true shape which is a circle.

To draw sectional plan, mark number of points on $a'g'$, at point c' the chord $c_1 c_1$ is the width of section at the point c'. Draw this in plan (circle) and locate point *cc* on this circle.

Similarly, locate the various points marked on cutting plane in the plan and join these points by smooth curve to obtain sectional plan.

Figure 4.46

(b)

Figure 4.47