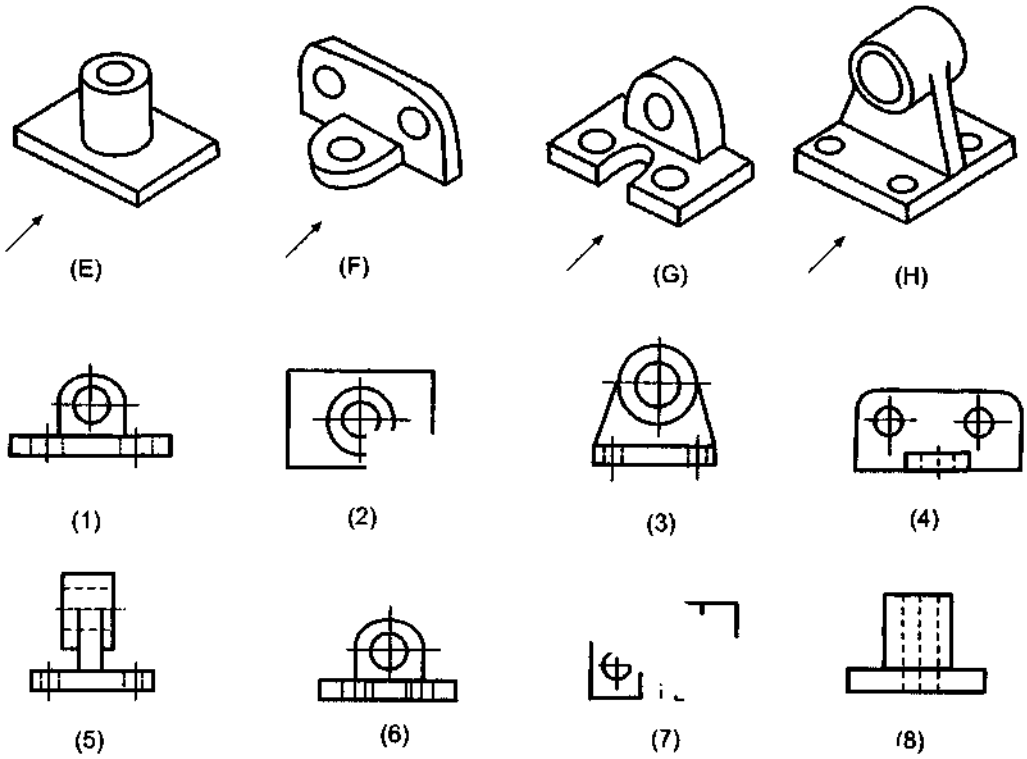
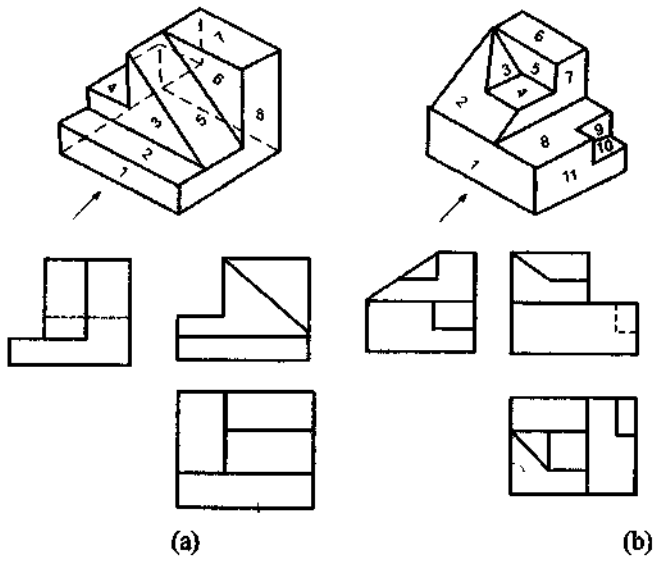
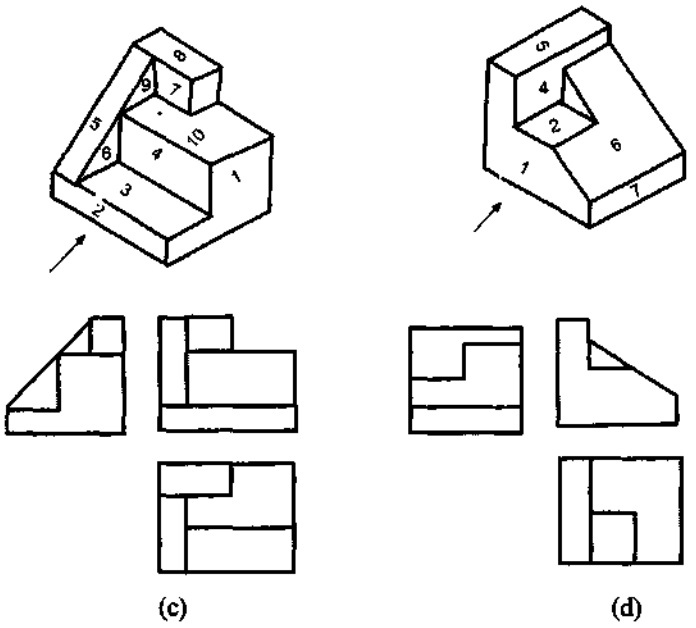


Fig. 6.74

Exercise 2

Study the isometric views in Figures 6.75 and identify the surfaces and number them looking in the direction of the arrows.



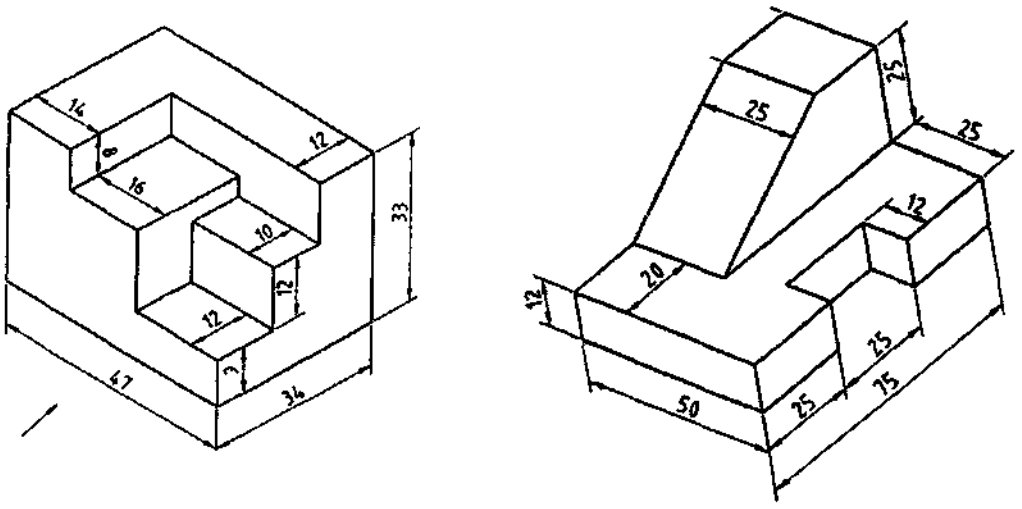


(c) (d)

Fig. 6.75

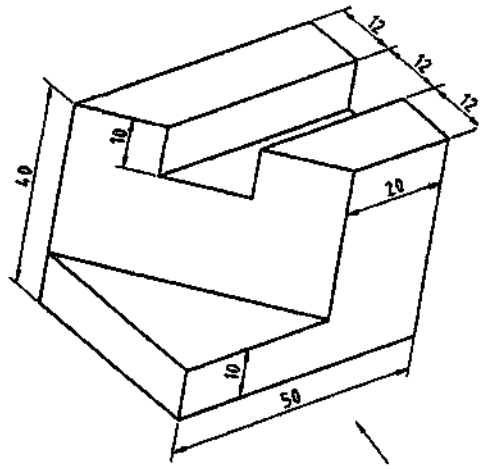
Exercise 3

Study the isometric views in Figures 6.76 and draw the orthographic views looking in the direction of the arrows and number the surfaces.

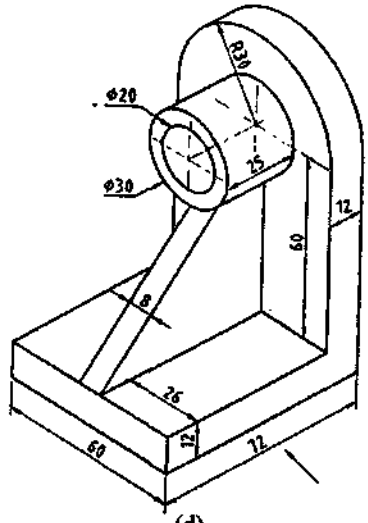


(a) (b)

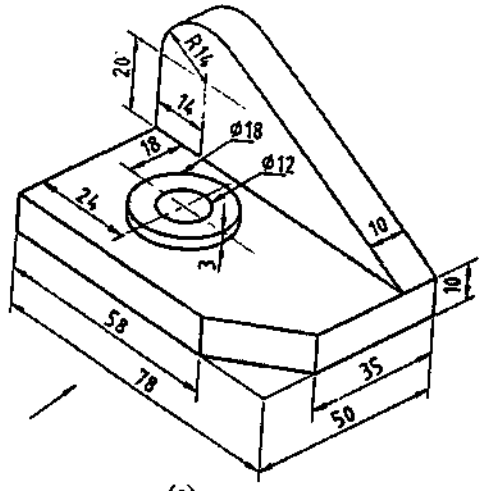
Fig. 6.76(a) &(b)



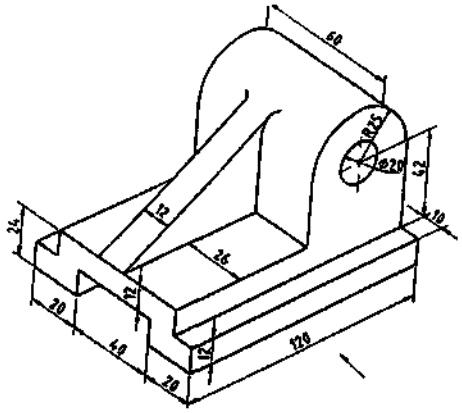
(c)



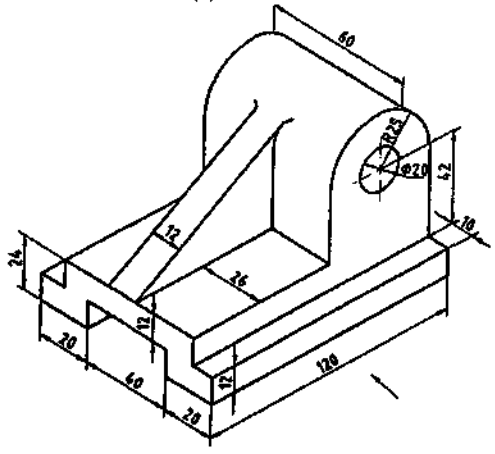
(d)



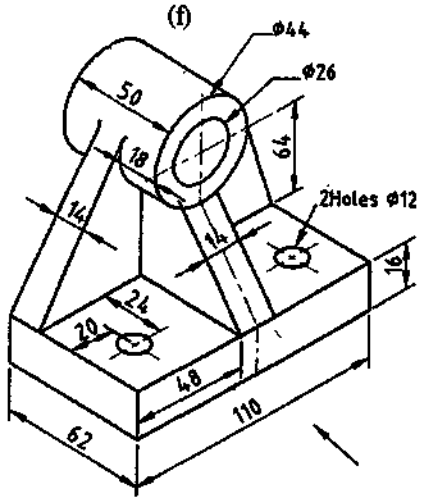
(e)



(f)



(g)



(h)

Fig. 6.76(e)(f)(g)&(b)

6.10 Auxiliary Projections

The conventional orthographic views, viz, front, top and side views may not be sufficient always to provide complete information regarding the size and true shape of the object, especially when it contains surfaces inclined to the principal planes of projections. The true shape of an inclined surface can only be obtained by projecting it on to an imaginary plane which is parallel to it. This imaginary plane is called an auxiliary plane and the view obtained on it is called the auxiliary view.

Fig 6.77

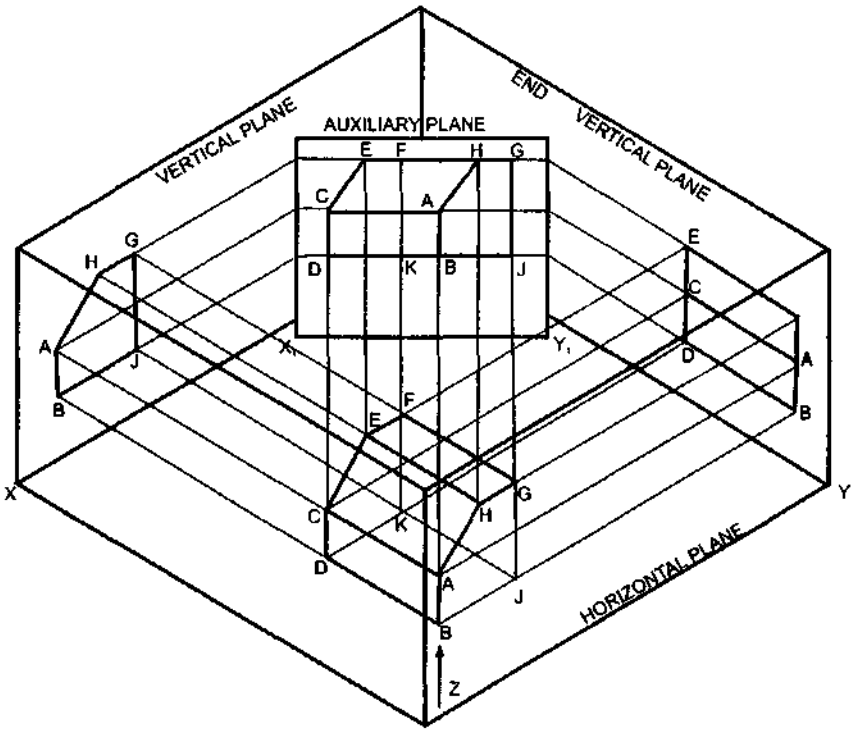


Fig. 6.77

In Fig. 6.77 the auxiliary view required is a view in the direction of the arrow Z. The top view is omitted for clarity. The object is in the first quadrant. The view in the direction of the arrow is obtained by projecting on to a plane at right angles to the arrow Z. This is a Vertical Plane containing the line x_1-y_1. The corners are projected on to the Auxiliary Vertical Plane (AVP) to obtain the auxiliary view as shown. Since the auxiliary plane is vertical, the edges AB, CD, GJ and FK are vertical and will be of true lengths on the auxiliary view. All other lengths are inclined to the auxiliary plane. The auxiliary view thus obtained will not be of much use to see the true shape of the inclined plane.

The advantage of auxiliary projections to see the true shape of the inclined surfaces is illustrated in Fig. 6.78(a).

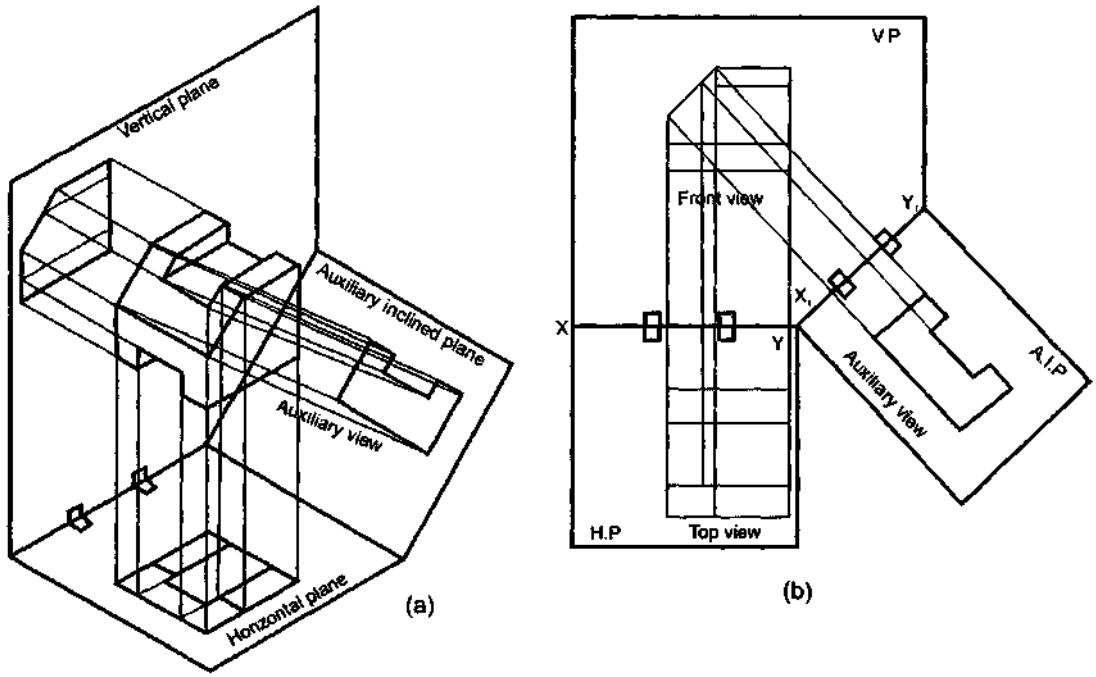


Fig. 6.78

As the auxiliary view only shows the true shape and details of the inclined surface or feature, a partial auxiliary view pertaining to the inclined surface only is drawn. Drawing all other features lead to confusion of the shape discription.

6.10 Types of Auxiliary Views

Auxiliary views may be classified, based on the relation of the inclined surface of the object with respect to the principal planes of projections.

Auxiliary Front View

Figure 6.79 Shows the auxiliary front view of a cube, projected on an Auxiliary Vertical Plane (AVP), inclined to VP and perpendicular to HP. Here, the auxiliary front view is projected from the top view, and its height is same as the height of the front view.

Auxiliary Top View

Figure 6.80 shows the auxiliary top view of a cube, projected on an auxiliary vertical plane inclined to VP and perpendicular to H.P. The diagonal of the cube is vertical and its front view is given. The auxiliary top view is projected from the front view and its depth is the same as the depth of the top view.

Primary and Secondary Auxiliary Views:

The auxiliary view obtained on either AIP or AVP is known as primary auxiliary view. The secondary auxiliary view is required to obtain the true shape of the surface when the surface of an object is inclined to both HP and VP.

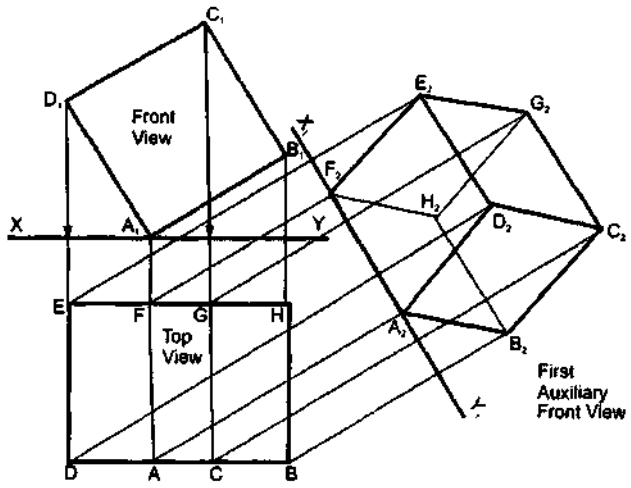


Fig. 6.79 First Auxiliary Front View

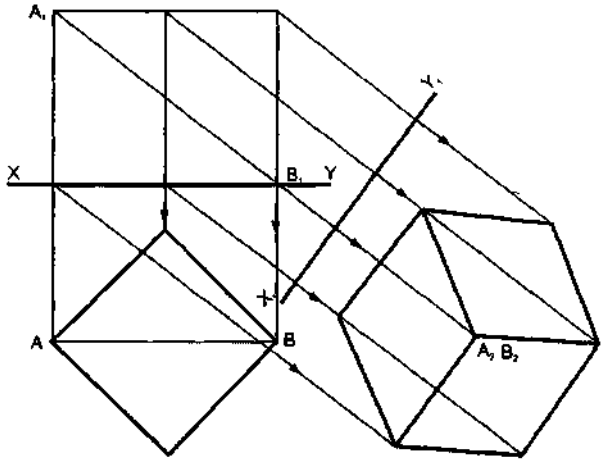


Fig. 6.80 First Auxiliary Top View

Auxiliary Projection of Regular Solids

Projection of planes and of regular solids inclined to one or both the principal planes of projection may be obtained by the use of auxiliary planes. This method is known as the change of reference line method. The advantage of the method may be understood from the examples below.

Problem : A hexagonal prism with a side of base 25mm and axis 60mm long is resting on one of its rectangular faces on H.P. Draw the projections of the prism when it is inclined at 45° to V.P.

Construction (Fig. 6.81)

1. Draw the projection of the prism assuming that the axis is perpendicular to VP, with one of its rectangular faces on H.P.

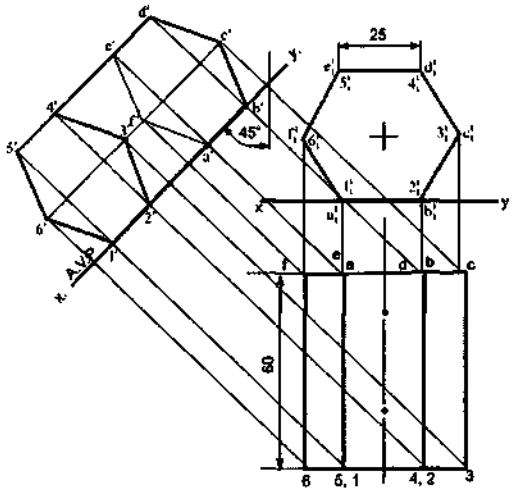


Fig. 6.81

2. Draw the reference line X_1-Y_1 at any Convenient location representing AVP and inclined at 45° to the axis of the initial top view.
3. Draw projectors perpendicular to X_1, Y_1, from all the corners in the top view.
4. Measure the distances of the corners in the front view from XY, corresponding to the above corners and mark from X_1,Y_1, along the above projectors.
5. Join the points in the order and complete the auxiliary front view.

The auxiliary view and the initial top view are the final views of the prism.

Problem : *A pentagonal pyramid with side of base 25mm and axis 50mm long, is resting on one of its slant faces on HP, such that its axis is parallel to VP. Draw the projections*

Construction (Fig. 6.82)

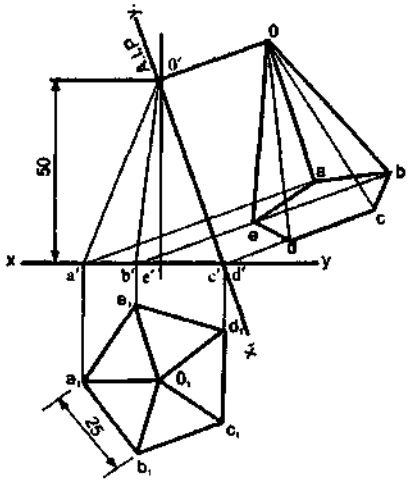


Fig. 6.82

1. Assuming that the axis is perpendicular to HP draw the projections, keeping an edge of the base perpendicular to xy, in the top view.
2. Draw the reference line x_1,y_1 (AIP), passing through the line in the front view, representing the slant face.
3. Repeat the steps 4 and 5 in Fig 6.81 and complete the auxiliary view as shown.

Problem : *Figure 6.83 shows the two views of a truncated octagonal pyramid. Obtain the true shape of the truncated surface of the solid by auxiliary projection.*

Construction (Fig 6.83)

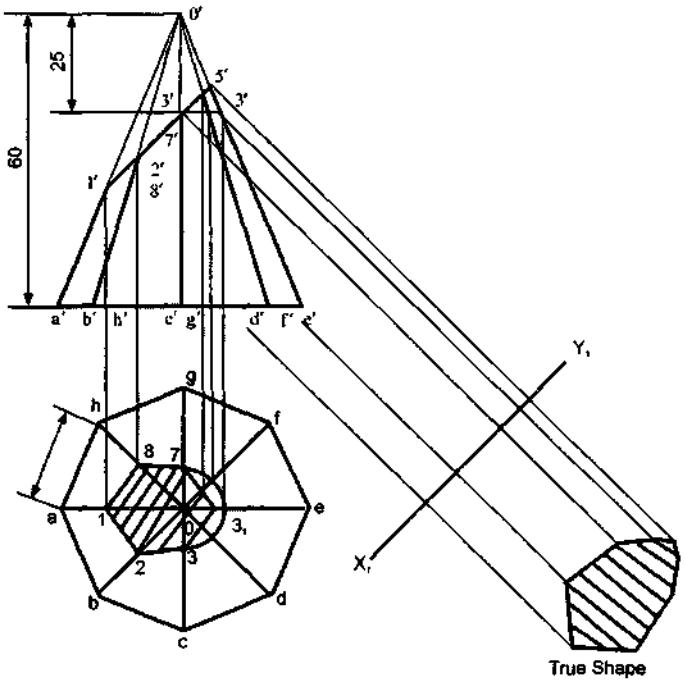


Fig. 6.83

EXERCISES

1. A cube of side 40mm rests on its base in HP. It is then rotated such that one of its vertical faces makes an angle of 30° to VP. Draw the projection of the cube.
2. A pentagonal prism with side of base 25mm and axis 50mm long is lying on HP on one of its faces. Draw the projections of the prism, when the axis is parallel to VP.
3. A hexagonal pyramid of side 30mm and height 60mm is resting with its base on HP. One of the base edges is inclined at 60° to VP. Draw its projections.
4. A regular pentagonal prism of side 30mm and height 60mm is resting on a corner such that one of its rectangular faces incline at 45° to the VP and perpendicular to HP. Draw its projection.

5. Draw the projection of cylinder with diameter of the base 40mm and axis 70mm long with its axis perpendicular to VP and 35mm above HP; one and being 10mm away from VP.
6. A pentagonal pyramid of base 30mm and axis 60mm long has its apex in the VP and the axis in perpendicular to VP. A corner of the base is resting on the ground and the sode of the base contained by the corner is inclined at 30° to the ground. Draw its projections.
7. Draw the projections of hexagonal pyramid of base 25mm and height 60mm when one of its triangular faces lies on HP, and its base edge is at right angle to the VP and the axis of the pyramid is parallel to VP.
8. One of the body diagonals of a cube of 40mm edge is parallel to HP and inclined at 60° to VP. Draw the projections of the cube.
9. Draw the projection of cylinder of 30mm diameter and 50mm long, lying on the ground with its axis inclined at 45° to the VP and parallel to the ground.
10. A cylinder of diameter 40mm and axis 80mm long is standing with its axis inclined at 30° to HP. Draw the projection.
11. Draw the projection of a right circular cone of 30mm diameter and 50mm height when a generator lines on HP making an angle of 30° with VP.
12. One of the body diagonals of a cube of 40mm edge is parallel to HP and inclined at 60° to VP. Draw the projections of the cube.

CHAPTER 7

Devlopment of Surfaces

7.1 Introduction

A layout of the complete surface of a three dimentional object on a plane is called the development of the surface or flat pattern of the object. The development of surfaces is very important in the fabrication of articles made of sheet metal.

The objects such as containers, boxes, boilers, hoppers, vessels, funnels, trays etc., are made of sheet metal by using the principle of development of surfaces.

In making the development of a surface, an opening of the surface should be determined first. Every line used in making the development must represent the true length of the line (edge) on the object.

The steps to be followed for making objects, using sheet metal are given below:

1. Draw the orthographic views of the object to full size.
2. Draw the development on a sheet of paper.
3. Transfer the development to the sheet metal.
4. Cut the development from the sheet.
5. Form the shape of the object by bending.
6. Join the closing edges.

Note: In actual practice, allowances have to be given for extra material required for joints and bends. These allowances are not cosidered in the topics presented in this chapter.

7.2 Methods of Development

The method to be followed for making the development of a solid depends upon the nature of its lateral surfaces. Based on the classification of solids, the folloiwing are the methods of development.

1. Parallel-line Development

It is used for developing prisms and single curved surfaces like cylinders in which all the edges / generators of lateral surfaces are parallel to each other.

2. Radial-line Development

It is employed for pyramids and single curved surfaces like cones in which the apex is taken as centre and the slant edge or generator (which are the true lengths)as radius for its development.

7.2.1 Develop[ment of Prism

To draw the development of a square prism of side of base 30mm and height 50mm.

Construction (Fig.7.1)

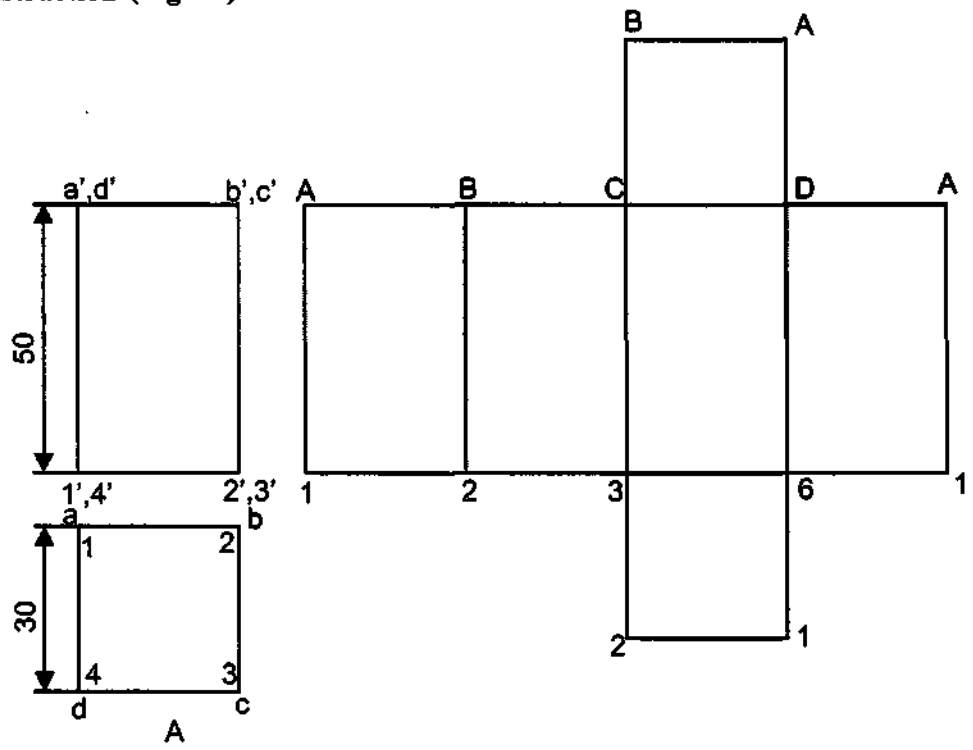


Fig. 7.1

1. Assume the prism is resting on its base on H.P. with an edge of the base pallel to V.P and draw the orthographic views of the square prism.
2. Draw the stretch-out line 1-1 (equal in length to the circumference of the square prism) and mark off the sides of the base along this line in succesion ie 1-2, 2-3, 3-4 and 4-1.
3. Errect perpendiculars through 1,2,3 etc., and mark the edges (folding lines) 1-A, 2-B, etc., equal to the height of the prism 50 mm.
4. Add the bottom and top bases 1234 and ABCD by the side of any of the base edges.

7.2.2 Development of a Cylinder

Construction (Fig.7.2)

Figure shows the development of a cylinder. In this the length of the rectangle representing the develoopmet of the lateral surface of the cylinder is equal to the circumference (πd here d is the diameter of the cylinder) of the circular base.

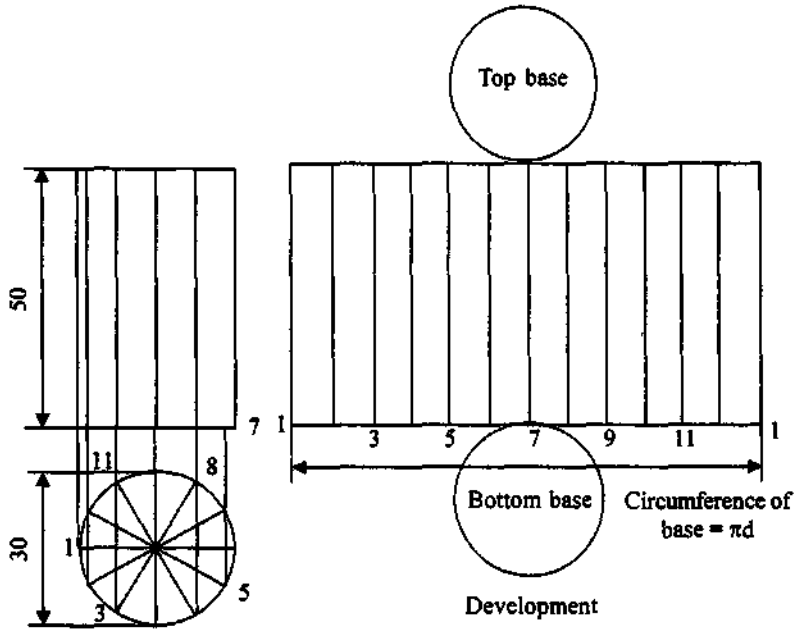


Fig. 7.2 Development of Cylinder

7.2.3 Development of a square pyramid with side of base 30 mm and height 60 mm.

Construction (Fig.7.3)

1. Draw the views of the pyramid assuming that it is resting on H.P and with an edge of the base parallel to V.P.
2. Determine the **true length o-a** of the slant edge.

Note:

In the orientation given for the solid, all the slant edges are inclined to both H.P and V.P. Hence, neither the front view nor the top view provides the true length of the slant edge. To determine the true lehiter of the slant edge, say OA, rotate **oa** till it is parallel to xy to the position.$\mathbf{oa}_1$. Through $\mathbf{a}_1$, draw a projector to meet the line xy at $\mathbf{a'}_1$. Then $\mathbf{o'}_1\ \mathbf{a'}_1$ represents the true length of the slant edge OA. This method of determining the true length is also known as rotation method.

3. with centre **o** and radius **o'a'** draw an arc.
4. Starting from A along the arc, mark the edges of the base ie. AB, BC, CD and DA.
5. Join O to A,B,C, etc., representaing the lines of folding and thus completing the development.

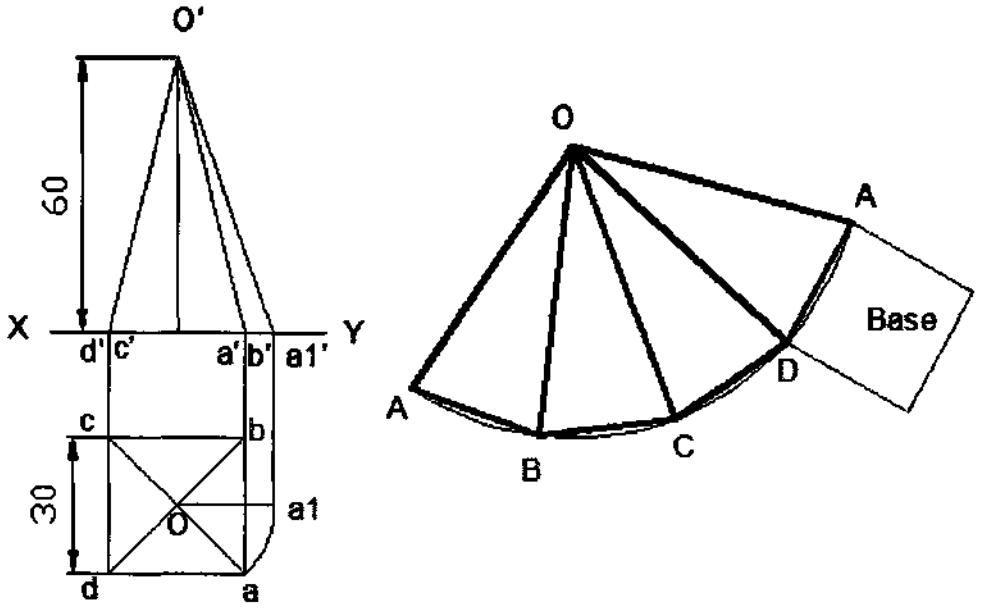


Fig. 7.3 Development of Square Pyramid

Development of Pentagonal Pyramid.

Construction (Fig.7.4)

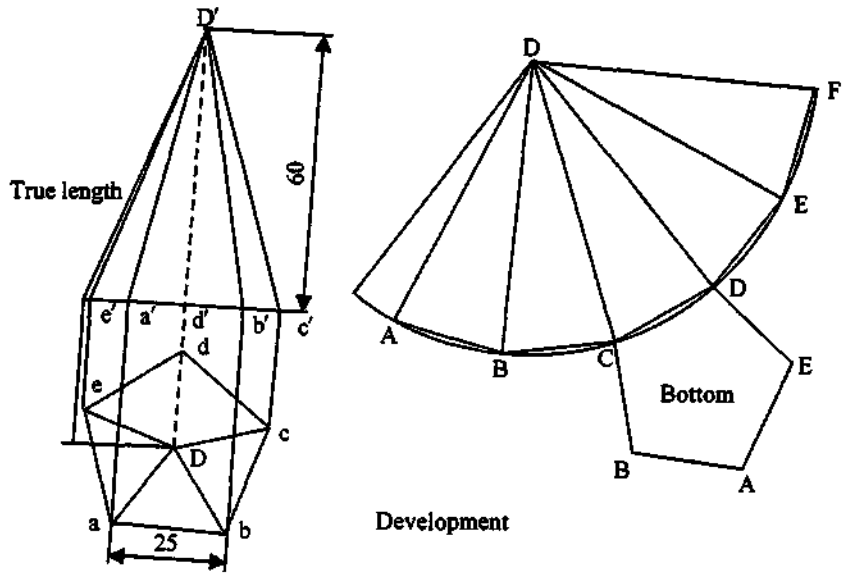


Fig. 7.4 Development of Pentagonal Pyramid

1. Draw the orthgraphic views of the pyramid ABCDE with its base on H.P and axis parallel to V.P.
2. With centre o of the pyramid and radius equal to the true length of the slant edge draw an arc.
3. Mark off the edges starting from A along the arc and join them to o representing the lines of folding.
4. Add the base at a suitable location.

7.2.4 Development of a Cone

Construction (Fig.7.5)

The development of the lateral surface of a cone is a sector of a circle. The radius and length of the arc are equal to the slant height and circumference of the base of the cone respectively. The included angle of the sector is given by $(r / s) \times 360^0$, where r is the radius of the base of the cone and s is the true length.

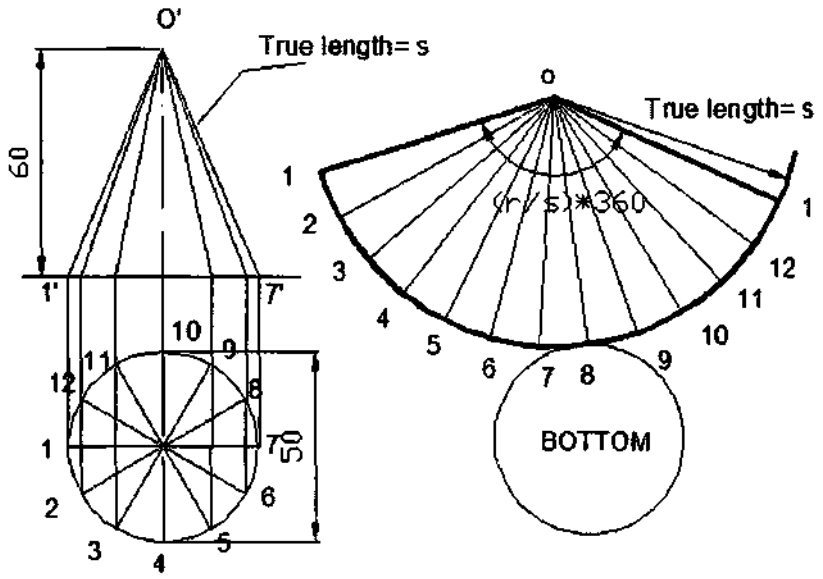


Fig. 7.5 Development of Cone

Problem : A Pentagonal prism of side of base 20 mm and height 50 mm stands vertically on its base with a rectangular face perpendicular to V.P. A cutting plane perpendicalar to V.P and inclined at 60^0 to the axis passes through the edges of the top base of the prism. Develop the lower portion of the lateral surface of the prism.

Construction (Fig.7.6)

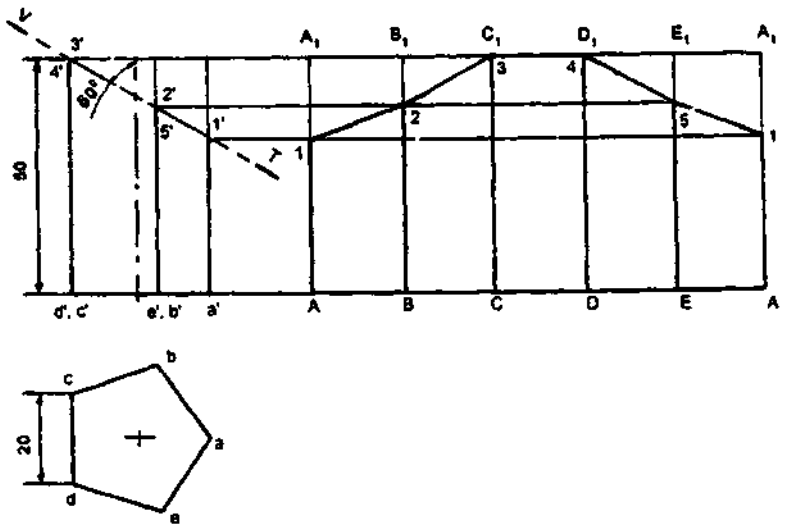


Fig. 7.6 Development of Pentagonal Prism

1. Draw the projections of the prism.
2. Draw the trace (V.T) of the cutting plane intersecting the edges at points 1,2,3, etc.
3. Draw the stretch-out AA and mark-off the sides of the base along this in succession i.e., AB, BC, CD, DE and EA.
4. Errect perpendiculars through A,B,C etc., and mark the edges AA_1, BB_1, equal to the height of the prism.
5. Project the points $1^1,2^1,3^1$ etc., and obtain 1,2,3 etc., respectively on the corresponding edges in the development.
6. Join the points 1,2,3 etc., by straight lines and darken the sides corresponding to the truncated portion of the solid.

Note

1. Generally, the opening is made along the shortest edge to save time and soldering.
2. Stretch-out line is drawn in-line with bottom base of the front view to save time in drawing the development.
3. AA_1-A_1A is the development of the complete prism.
4. Locate the points of intersectiion $1^1,2^1$, etc., between VT and the edges of the prism and draw horizontal lines through them and obtain 1,2, etc., on the corresponding edges in the devolopment
5. Usually, the lateral surfaces of solids are developed and the ends or bases are omitted in the developments. They can be added whenever required easily.

Problem : *A hexagonal prism of side of base 30 mm and axis 70 mm long is resting on its base on H.P. such that a rectangular face is parallel to V.P. It is cut by a section plane perpendicular to V.P and inclined at 30⁰ to H.P. The section plane is passing through the top end of an extreme lateral edge of the prism. Draw the development of the lateral surface of the cut prism.*

Construction (Fig.7.7)

1. Draw the projections of the prism.
2. Draw the section plane VT.
3. Draw the development AA_1-A_1A of the complete prism following the stretch out line principle.
4. Locate the point of intersectiion 1^1, 2^1 etc., between VT and the edges of the prism.
5. Draw horizontal lines thrugh 1^1,2^1 etc., and obtain 1,2, etc., on the corresponding edges in the development.
6. Join the points 1,2, etc., by straight lines and darken the sides corresponding to the retained portion of the solid.

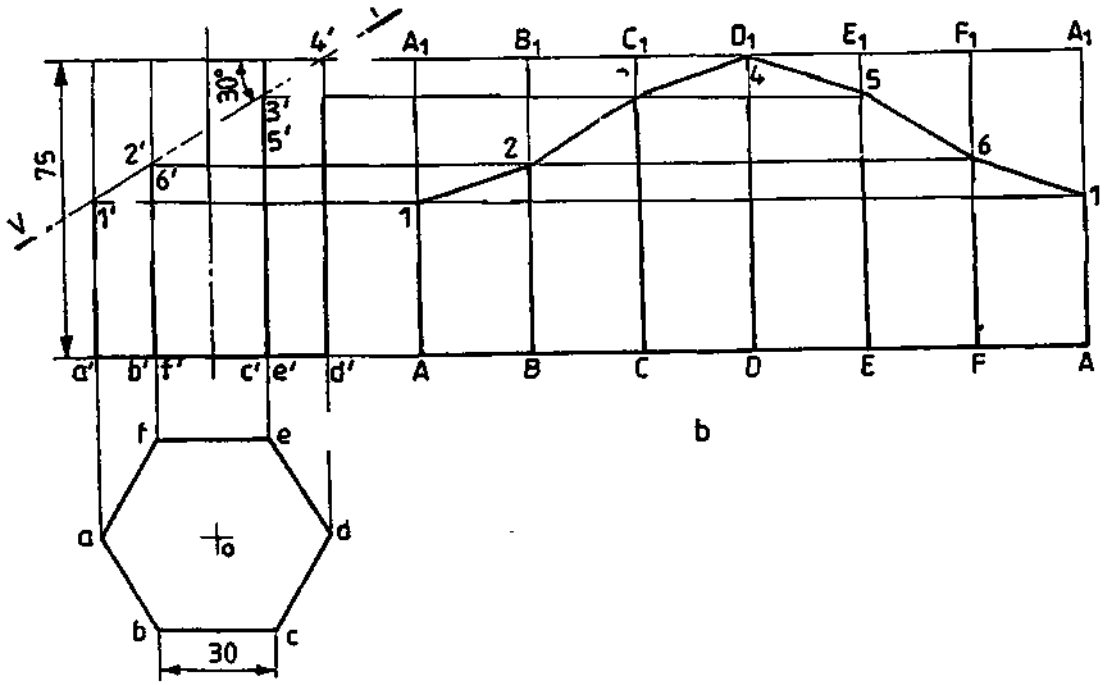


Fig. 7.7 Development of Hexagonal Prism

Problem : *Draw the development of the lateral surface of the frustum of the square pyramid of side of base 30 mm and axis 40 mm, resting on H.P with one of the base edges parallel to V.P. It is cut by a horizontal cutting plane at a height of 20 mm.*

Construction (Fig.7.8)

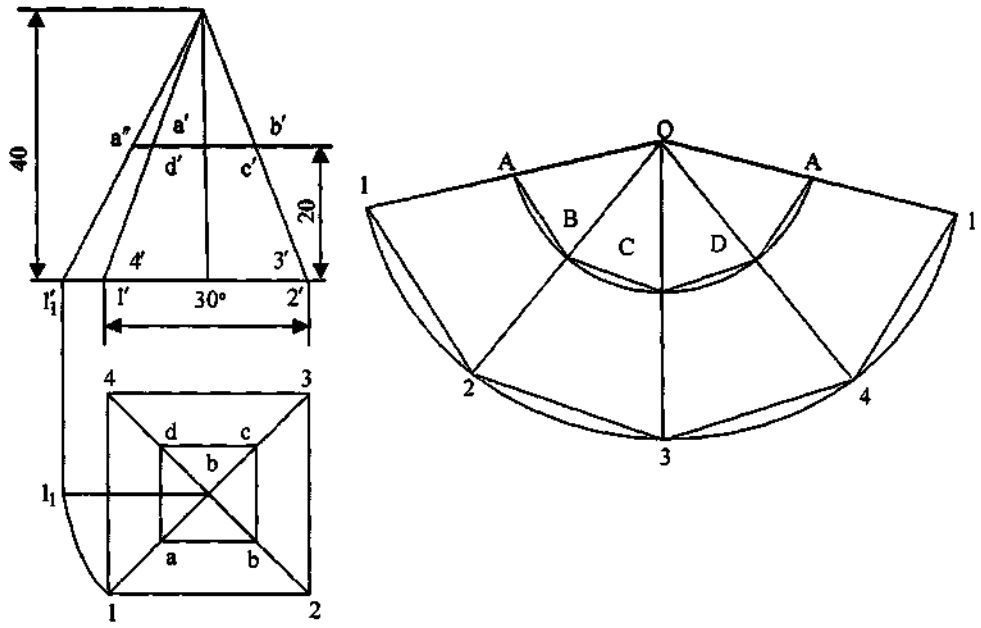


Fig. 7.8 Development of Frustum of Square Pyramid

1. Draw the projections of the square pyramid.
2. Determine the true length. **o-a** of the slant edge.
3. Draw the trace of the cutting plane VT.
4. Locate the points of instersection of the cutting plane on the slant edges a'b'c'd' of the pyramid.
5. With any point **o** as centre and radius equal to the true length of the slant edge draw an arc of the circle.
6. With radius equal to the side of the base 30 mm, step-off divisions on the above arc.
7. Join the above division points 1,2,3 etc., in the order with the centre of the arc **o**. The full development of the pyramid is given by 012341.
8. With centre **o** and radius equal to **oa** mark-off these projections at A, B, C, D, A. Join A-B, B-C etc. ABCDA-12341 is the development of the frustum of the square pyramid.

Problem : *A hexagonal pyramid with side of base 30 mm and height 75 mm stands with its base on H.P and an edge of the base parallel to V.P. It is cut by a plane perpendicular to V.P, inclined at 45° to H.P and passing through the mid-point of the axis. Draw the (sectioned) top view and develop the lateral surface of the truncated pyramid.*

Construction (Fig.7.9)

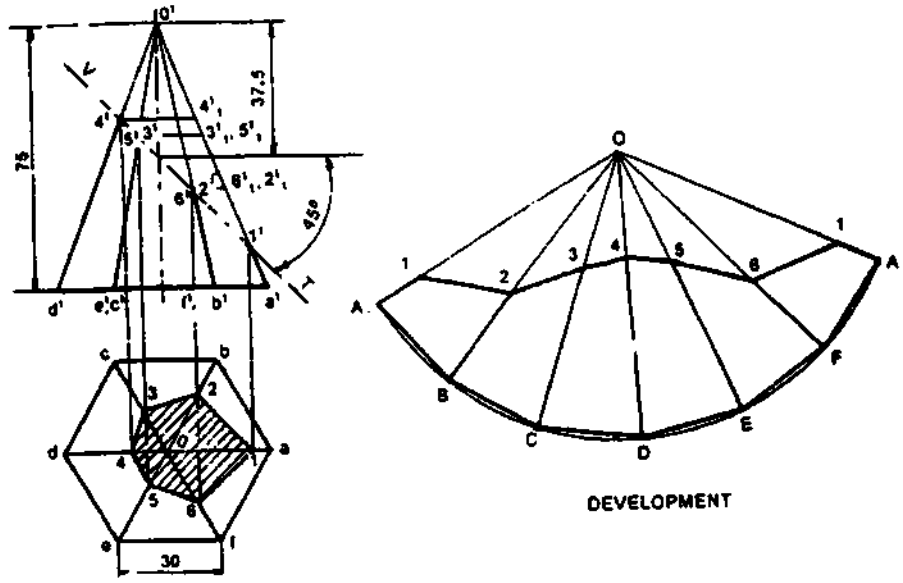


Fig. 7.9 Development of Frustum of Square Pyramid

1. Draw the two views of the given pyramid and indicate the cutting plane.
2. Locate the points of interseciton $1^1,2^1,3^1,4^1,5^1$ and 6^1 between the slant edges and the cutting plane.
3. Obtain the sectional top view by projecting the above points.
4. With o as centre and radius equal to the true length of the slant edge draw an arc and complete the total development by following construction of Fig.7.8.
5. Determine the true length $o^12^1_1$, $o^13^1_1$, etc., of the slant edges o^12^1, o^13^1, etc.

Note

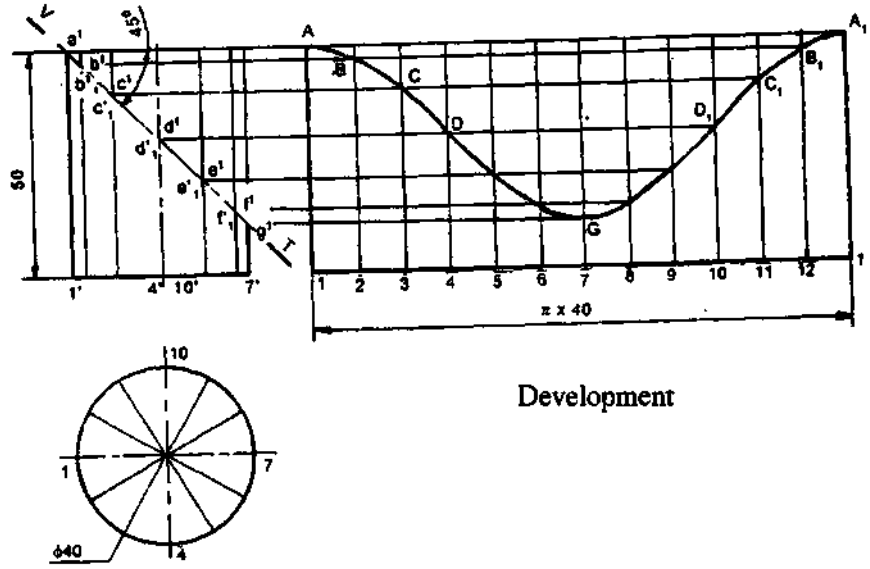
(i) To determine the true tength of the edge, say o^12^1, through 2^1 draw a line parallel to the base, meeting the true length line **o-a** at 2^1_1. The length $o^12^1_1$ represents the true length of o^12^1.

(ii) o^11^1 and o^14^1 represent the true lengths as their top views (o1, o4) are parallel to xy.

6. Mark 1,2,3 etc., along OA,OB,OC etc., corresponding to the true lengths o^11^1, o^12^1, o^13^1, etc., in the development.
7. Join 1,2,3 etc., by straight lines and darken the sides corresponding to the truncated portion of the solid.

Problem : *A cylinder of diameter of base 40 mm and height 50 mm is standing on its base on H.P. A cutting plane inclined at 45° to the axis of the cylinder passes through the left extreme point of the top base. Develop the lateral surface of the truncated cylinder.*

Construction (Fig.7.10)



Development

Fig. 7.10

1. Draw the views of the truncated cylinder.
2. Divide the circle (top view) into an equal number of parts.
3. Draw the genertors in the front view corresponding to the above division points.
4. Mark the points of intersection $a^1, b^1, b^1_1, c^1, c^1_1$, etc., between the truncated face and the generators.
5. Draw the stretch-out line of length equal to the circumference of the base circle.
6. Divide the stretch-out line into the same number of equal parts as that of the base circle and draw the generators through those points.
7. Project the points a,b,c, etc., and obtain A,B,C, etc., respectively on the corresponding generators 1,2,3 etc., in the development.
8. Join the points A,B,C etc., by a smooth curve.

Note

(i) The generators should not be drawn thick as they do not represent the folding edges on the surface of the cylinder.

(ii) The figure bounded by $1A\text{-}A_1 1$ represents the development of the complete cylinder.

Problem : *A cylinder of base 120 mm and axis 160 mm long is resting on its base on H.P. It has a circular hole of 90 mm diameter, drilled centrally through such that the axis of the hole is perpendicular to V.P and bisects the axis of the cylinder at right angles. Develop the lateral surface of the cylinder.*

Construction (Fig.7.11)

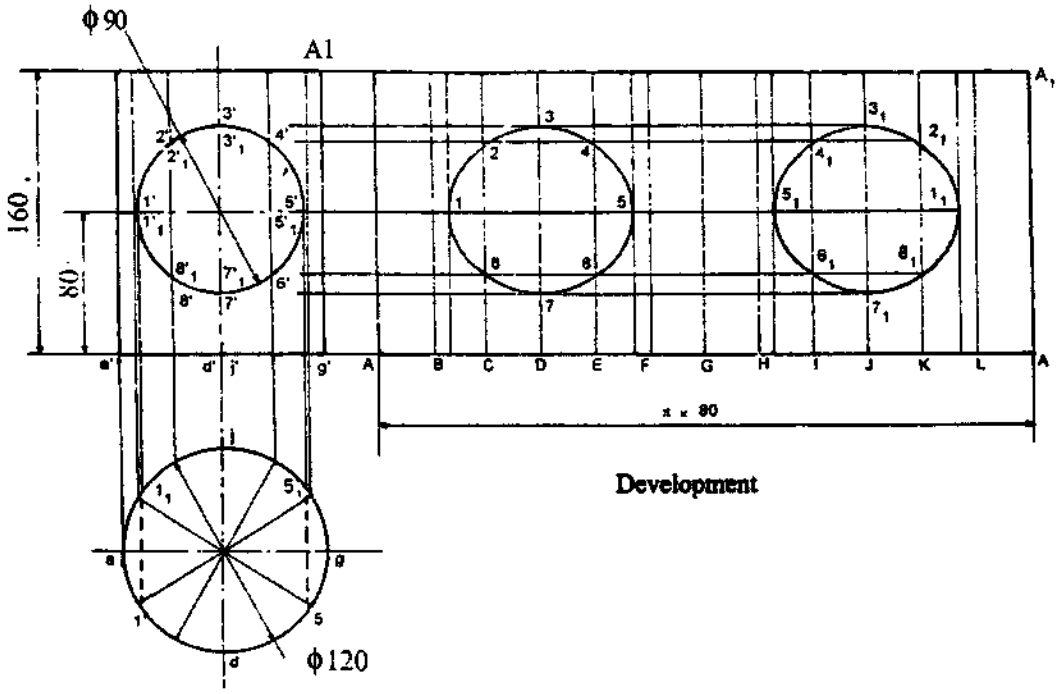


Fig. 7.11

1. Draw the projections of the cylinder with the hole through it.
2. Divide the circle (top view) of the cylinder into 12 equal parts and locate the corresponding generators in the front view.
3. Obtain the complete development AA^1, A^1A of the cylinder and locate the generatros on it.
4. Determine the points of intersection $1^1,2^1$, etc and $1^1_1,2^1_1$, etc. between the hole and the generators in the front view.
5. Transfer these points to the development by projection, including the transition points $1^1(1^1_1)$ and $5^1(5^1_1)$.
6. Join the points 1,2 etc., and $1_1,2_1$, etc., by smooth curves and obtain the two openings in the development.

Problem : *A cone of diameter of base 45 mm and height 60 mm is cut by horizontal cutting plane at 20 mm from the apex. Draw the devleopment of the truncated cone.*

Consturction (Fig.7.12)

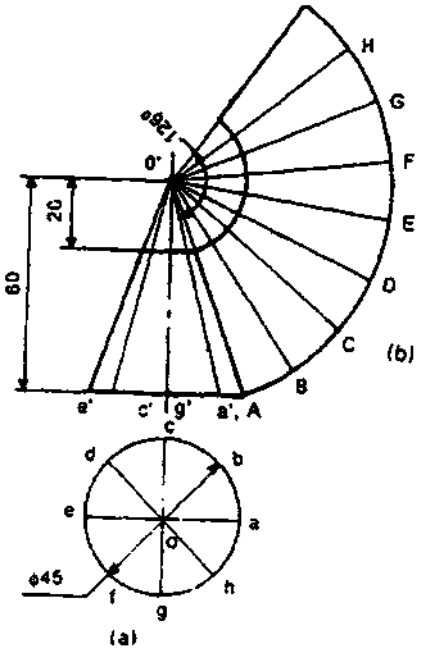


Fig.7.12

1. Draw the two views of the given cone and indicate the cutting plane.
2. Draw the lateral surface of the complete cone by a sector of a circle with radius and arc length equal to the slant hight and circumference of the base respectively. The included anlgle of the sector is given by (360 x r/s), where r is the radius of the base and s is the slant height.
3. Divide the base (top view)into an equal number of parts, say 8.
4. Draw the generators in the front view corresponding to the above division points a,b,c etc.
5. With $o^1 1^1$ as radius draw an arc cutting the generators at 1,2,3 etc.
6. The truncated sector $A^1\text{-}1^1A$ gives the development of the truncated cone.

Problem : A cone of base 50mm diameter and height 60mm rests with its base on H.P. and bisects the axis of the cone. Draw the deveopment of the lateral surface of the truncated cone.

Construction (Fig.7.13)

1. Draw the two views of the given cone and indicate the cutting plane.
2. Draw the lateral surface of the complete cone.
3. Divide the base into 8 equal parts.
4. Draw the generators in the front view corresponding to the above divisions.
5. Mark the points of intersection 1,2,3 etc. between the cutting plane and the generators.
6. Trasfer the points 1,2,3 etc. to the development after finding the true distances of 1,2,3 etc from the apex **o** of the cone in the front view.

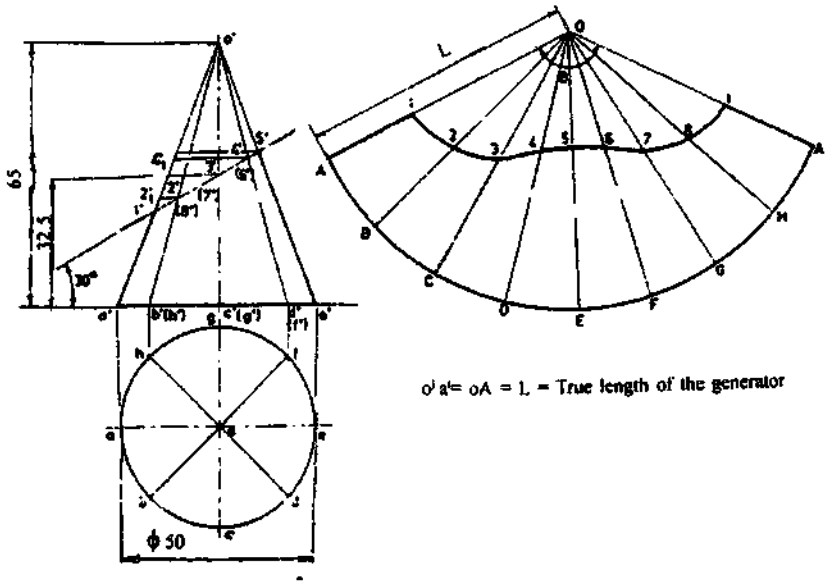


Fig. 7.13

Note : To transfer a point say 4 on **od** to the development.

(i) Determine the true length of **o-4** by drawing a horizontal through 4 meeting **od** at 4.

(ii) On the generator OD, mark the distance **o-4** equal to **o-4**.

Problem : *Figure 7.14a shows a tools tray with an allowance for simple hem and lap-seam. Figure 7.14b represents its development with dimensions.*

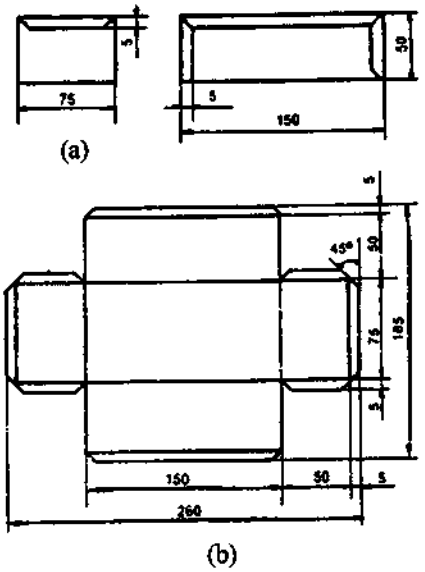


Fig. 7.14

Problem 15 : *Figure 7.15a shows a rectangualr scoop with allowance for lap-seam and Figure 7.15b shows the development of the above with dimensions.*

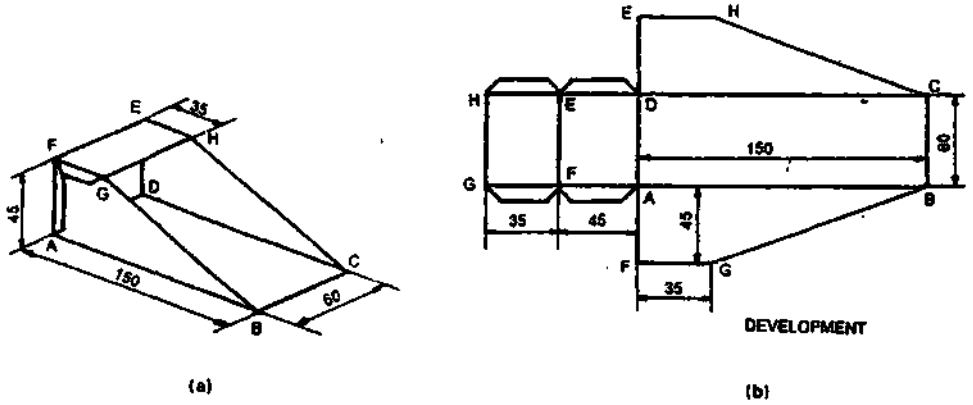


Fig. 7.15 Rectangular Scoop

Problem : *Figure 7.16a shows the pictorial view of a rectangular 90⁰ elbow and Figure 7.16b its development in two parts.*

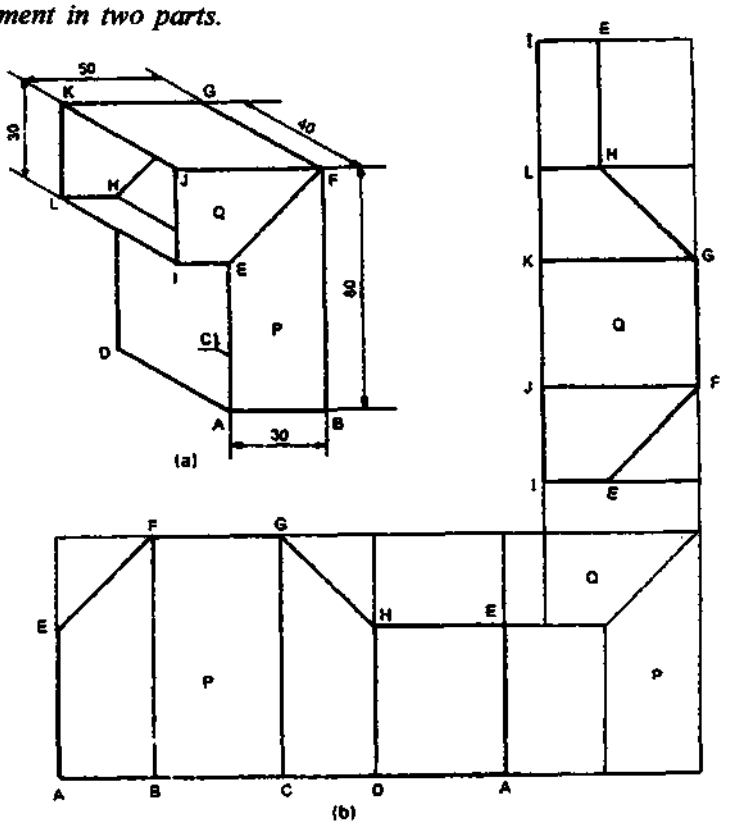


Fig. 7.16 Development of 90⁰ Elbow (Rectangular)

Problem : *Figure 7.17a represents the projection of a round scoop and Figure 7.17b its development.*

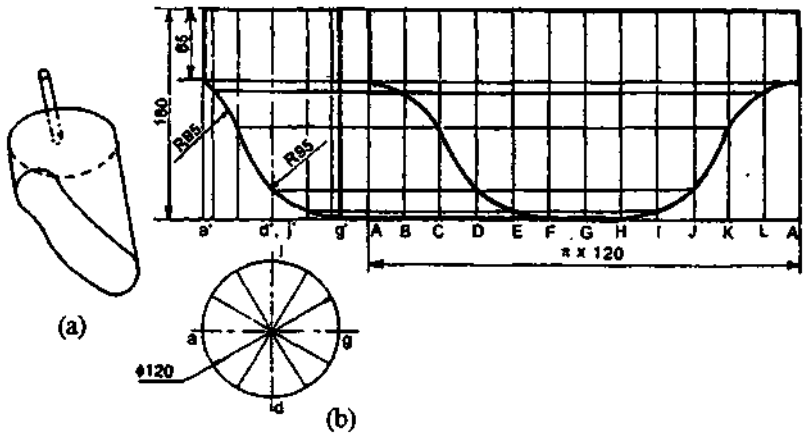


Fig. 7.17 Development of Round Scoop

Problem : *Figure 7.18 shows the projection of a 90o elbow of round section with development shown for one piece.*

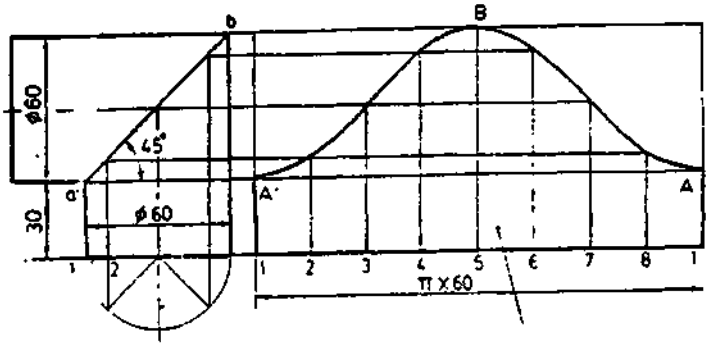


Fig. 7.18 Development of 90° Elbow (Round)

Problem : *Figure 7.19 shows the orthographic projection and the development of parts of funnel.*

Problem 20 : *Figure 7.20 shows the orthographic projection of a chute and the development of the parts.*

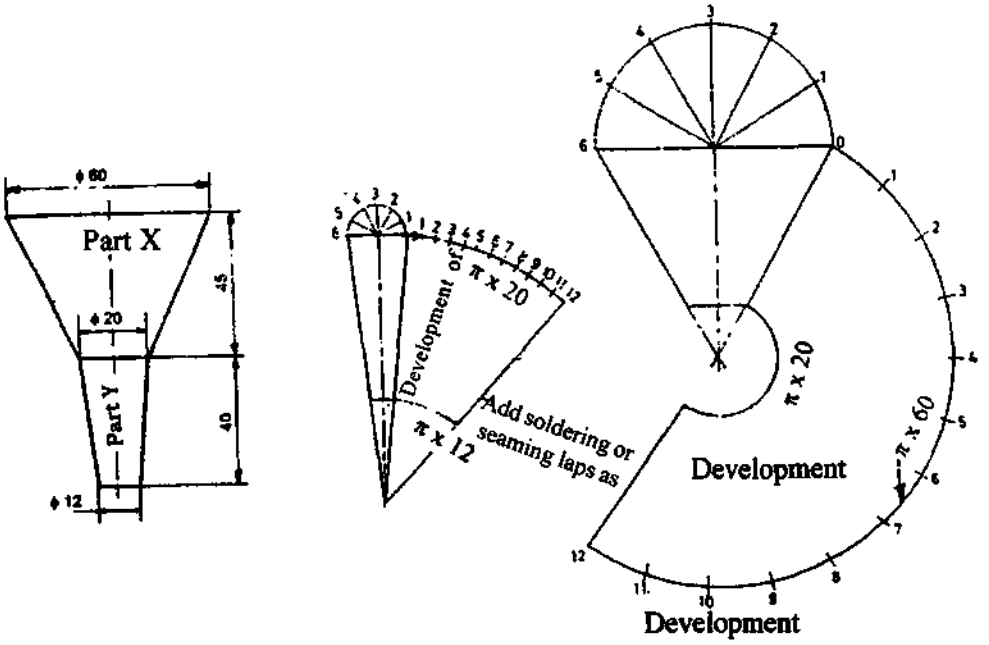


Fig. 7.19 Development of Funnel

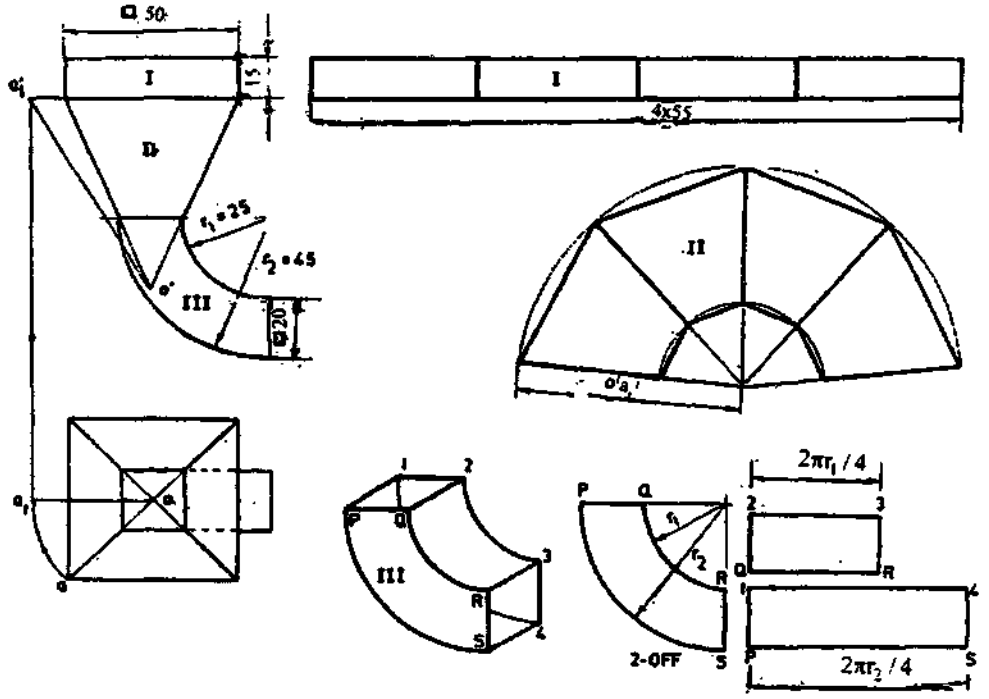


Fig. 7.20 Development of Chute

Problem : *Figure 7.21 shows the orthographic projection of measuring oil can and the development of its parts.*

Problem : *Figure 7.22 shows the development of a three piece pipe elbow.*

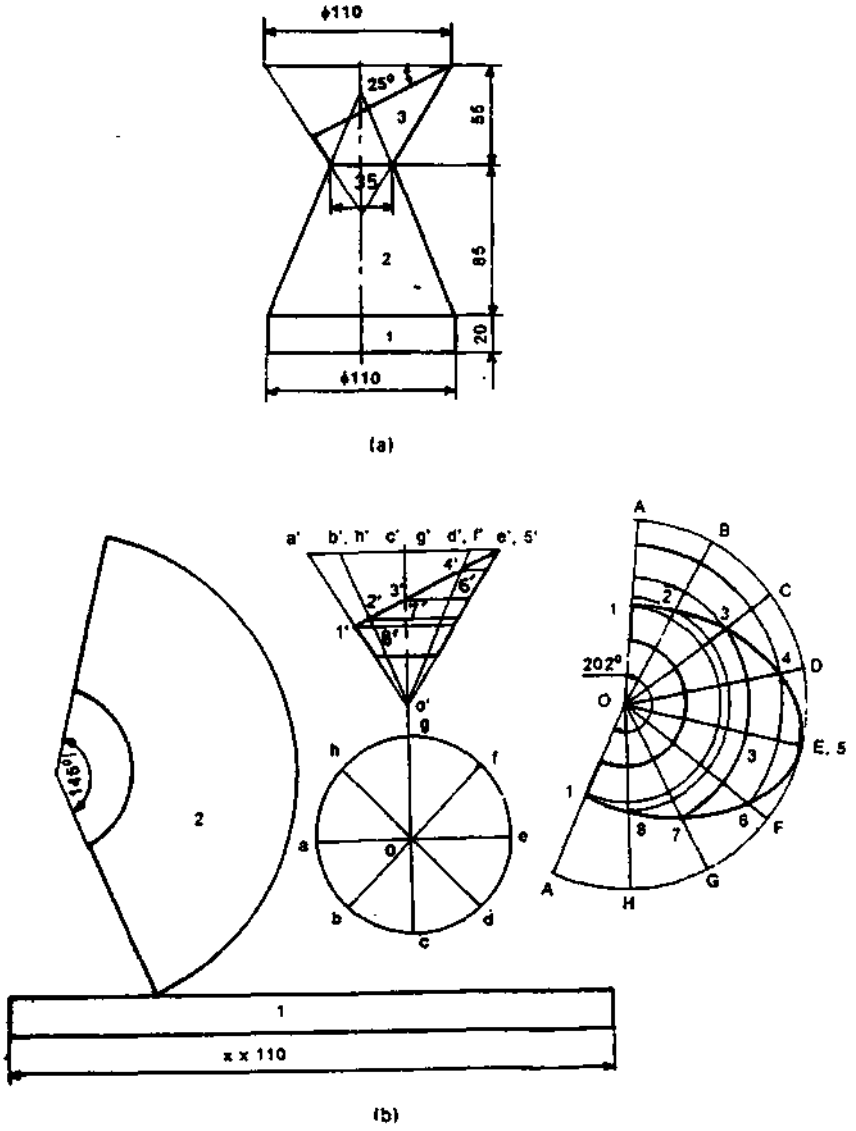


Fig. 7.21 Development of Mesuring Oil Can

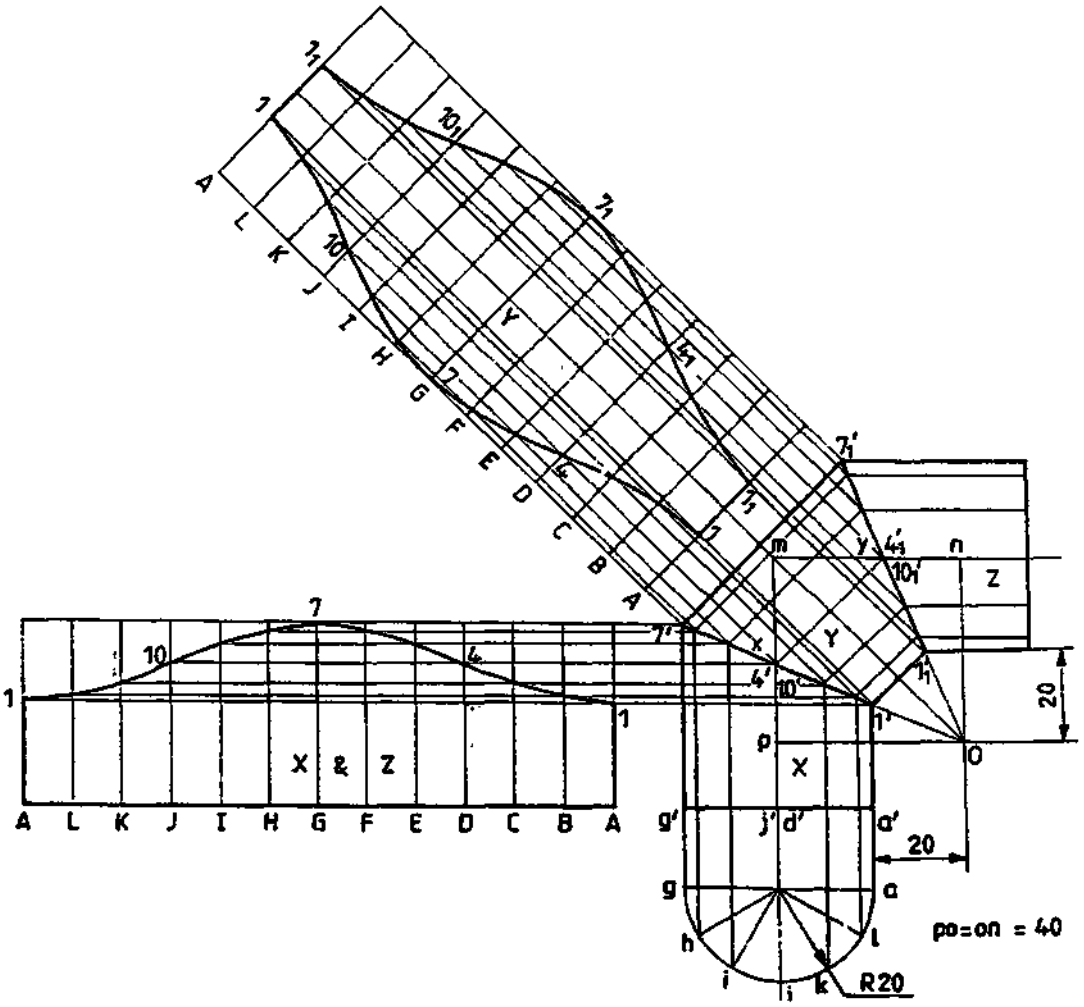


Fig. 7.22 Development of Three Piece Pipe Elbow

Examples

Problem : A hexagonal prism with edge of base 30 mm and height 80 mm rests on its base with one of its base edges perpendicular to V.P. An inclined plane at 45° to H.P. cuts its axis at its middle. Draw the development of the truncated prism.

Solution : (Fig.7.23)

Problem : A pentagonal pyramid, side of base 50 mm and height 80 mm rests on its base on the ground with one of its base sides parallel to V.P. A section plane perpendicular to VP and inclined at 30° to H.P cuts the pyramid, bisecting its axis. Draw the development of the truncated pyramid.

Solution : (Fig.7.24)

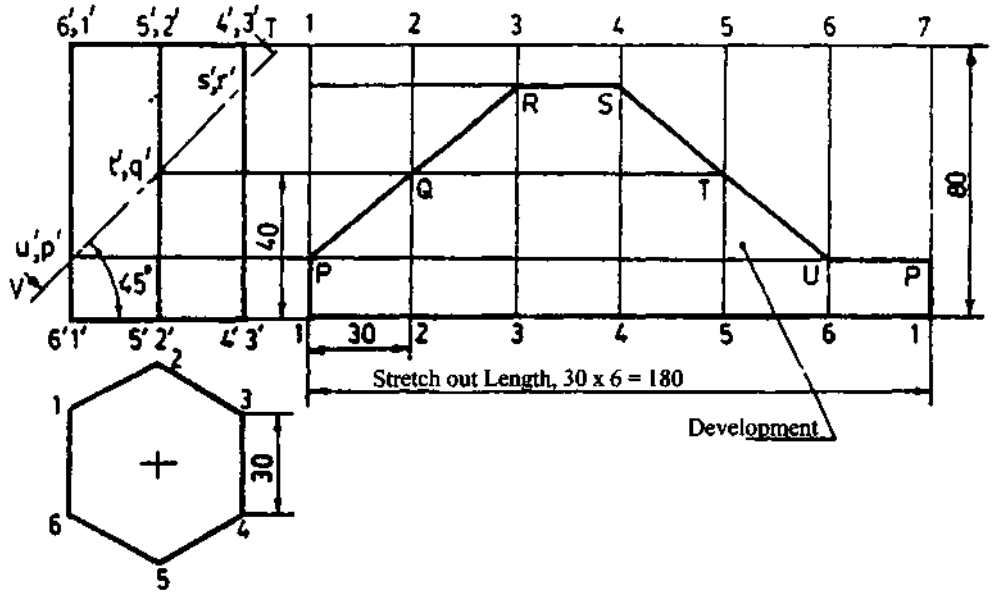


Fig. 7.23 Development of a Right Regular truncated Hexagonal Prism

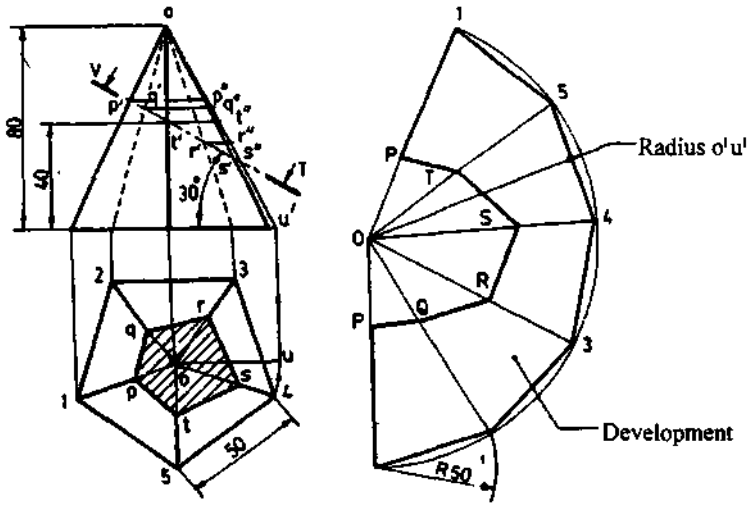


Fig. 7.24 Development of a Right Regular Truncated Pentagonal Pyramid

Problem : *Draw the development of a bucket shown in Fig.7.25a*

Solution : (Fig.7.25b)

Problem : Draw the development of the measuring jar shown in Fig.7.26a.

Solution : (Fig.7.26b)

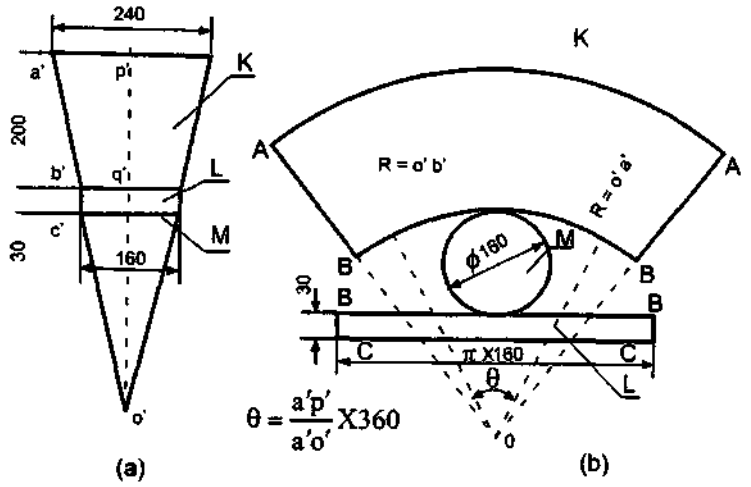


Fig. 7.25 Development of a Bucket

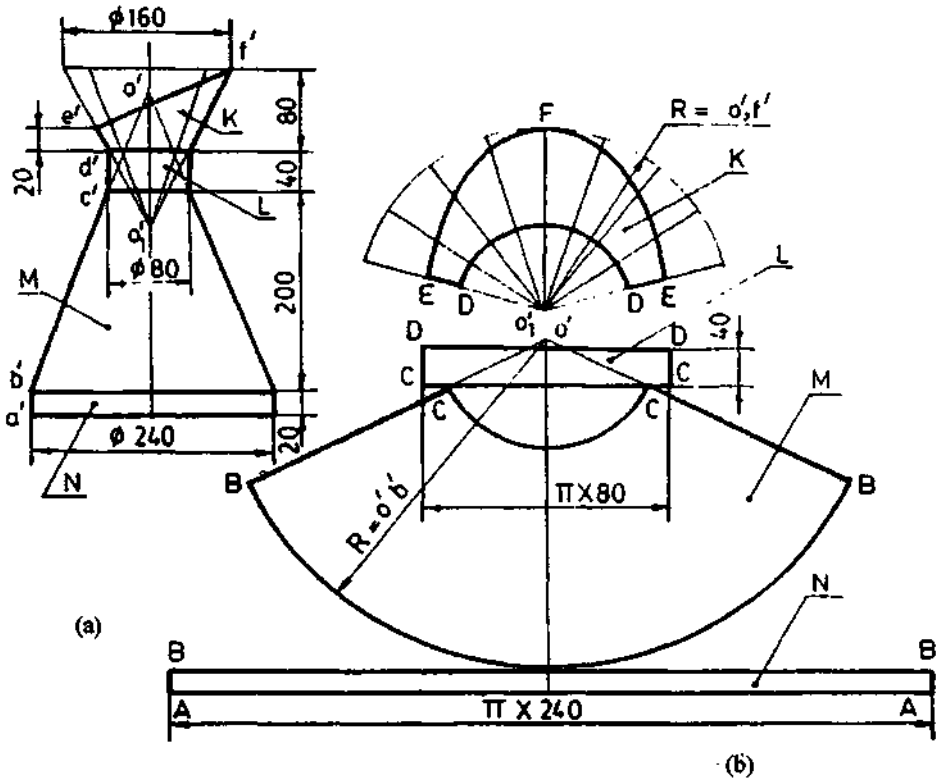


Fig. 7.26 Development of a Measuring Can

EXERCISE

Development of Surfaces

1. A frustrum of a square pyramid has its base 50 mm side, top 25 mm side and height 60 mm. It is resting with its base on HP, with two of its sides parallel to VP. Draw the projections of the frustrum and show the development of its lateral surface.
2. A cone of diameter 60 mm and height 80 mm is cut by a section plane such that the plane passes through the mid-point of the axis and tangential to the base circle. Draw the development of the lateral surface of the bottom portion of the cone.
3. A cone of base 50 mm diameter and axis 75 mm long, has a through hole of 25 mm diameter. The centre of the hole is 25 mm above the base. The axes of the cone and hole intersect each other. Draw the development of the cone with the hole in it.
4. A transition piece connects a square pipe of side 25 mm at the top and circular pipe of 50 mm diameter at the bottom, the axes of both the pipes being collinear. The height of the transition piece is 60 mm. Draw its development.
5. Figure 7.27 shows certain projections of solids. Draw the developments of their lateral surfaces.

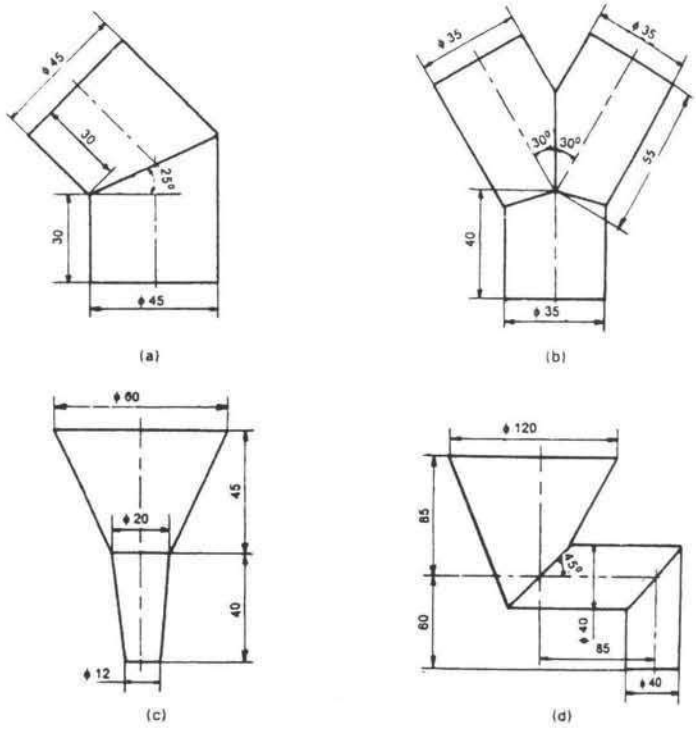


Fig. 7.27 ®