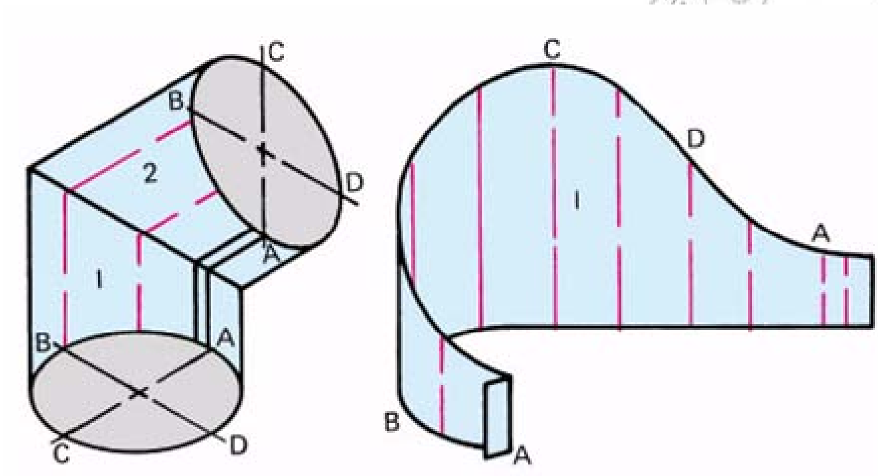
UNIT 5

DEVELOPMENT AND INTERSECTION



Learning Competencies:

Upon the completion of this unit, you should be able to:-

- ✓ **identify the various types of surfaces and solids;**
- ✓ **identify the types of hems and joints used in sheet metal working;**
- ✓ **prepare the pattern development of common solids like prism, cylinder , pyramid and cone;**
- ✓ **determine the line or curve of intersection of two intersecting solids such as prisms and cylinders.**

5.1. Introduction

What do you understand from development and intersection technically?
What do you think are the elements intersecting?
Can you give examples?

This unit deals with the two very important technical drawing concept, that is *developments* and *intersections*.

But before directly begin discussing the above two concepts. It is better to have a brief over view about the definition and description of basic geometrical elements such as point, line, surface and solid.

Point

Point is a theoretical representation of location of an element /object in space. It has no dimension i.e. height, width and depth.

Line

Line is one generated by a point moving according to a law which may be expressed by a geometric description or by an algebraic equation. It has one dimension i.e. only length.

Surface

Surface is a two dimensional geometrical figure, which may be generated by a motion of either straight or curved line. It is called the *generatrix* of the surface. Any position of the generatrix is an element of the surface. There are two types of surface: Ruled surfaces and double-curved surfaces.

I) A ruled surface: It is a surface generated by the motion of a straight line in a certain desired path. This type of surface may include planes, single-curved surfaces and surfaces.

A Plane is a ruled surface generated by moving a straight line along a line (lying in the same plane) in such a way that its new position of moved line is parallel to the original line. A Plane surface may have three or more sides.

A Single curved surface is a curved ruled surface that can be developed or unrolled to coincide with a plane. Any two adjacent positions of the generatrix of a single-curved surface lie in the same plane, for example cylinder and cone (Fig.5.1 (c) and (e)).

A warped surface is a curved ruled surface that cannot be developed; here no two adjacent positions of the generatrix lie in the same plane. Examples are helicoid and hyperboloid as shown in Fig.5.2. So we conclude that it is a surface that is neither plane nor curved e.g. the hoods on most automobile are warped surfaces.

II) Double-curved surface is one that may be generated by a curved line and thus has no straight line element. Examples are sphere, torus and ellipsoid (Fig.5.1 (f)).

Solid

Solid is a three dimensional representation of an object which may be generated by bounding plane surfaces or revolving of a plane figure about an axis. It shows height, width and depth dimensions of the object.

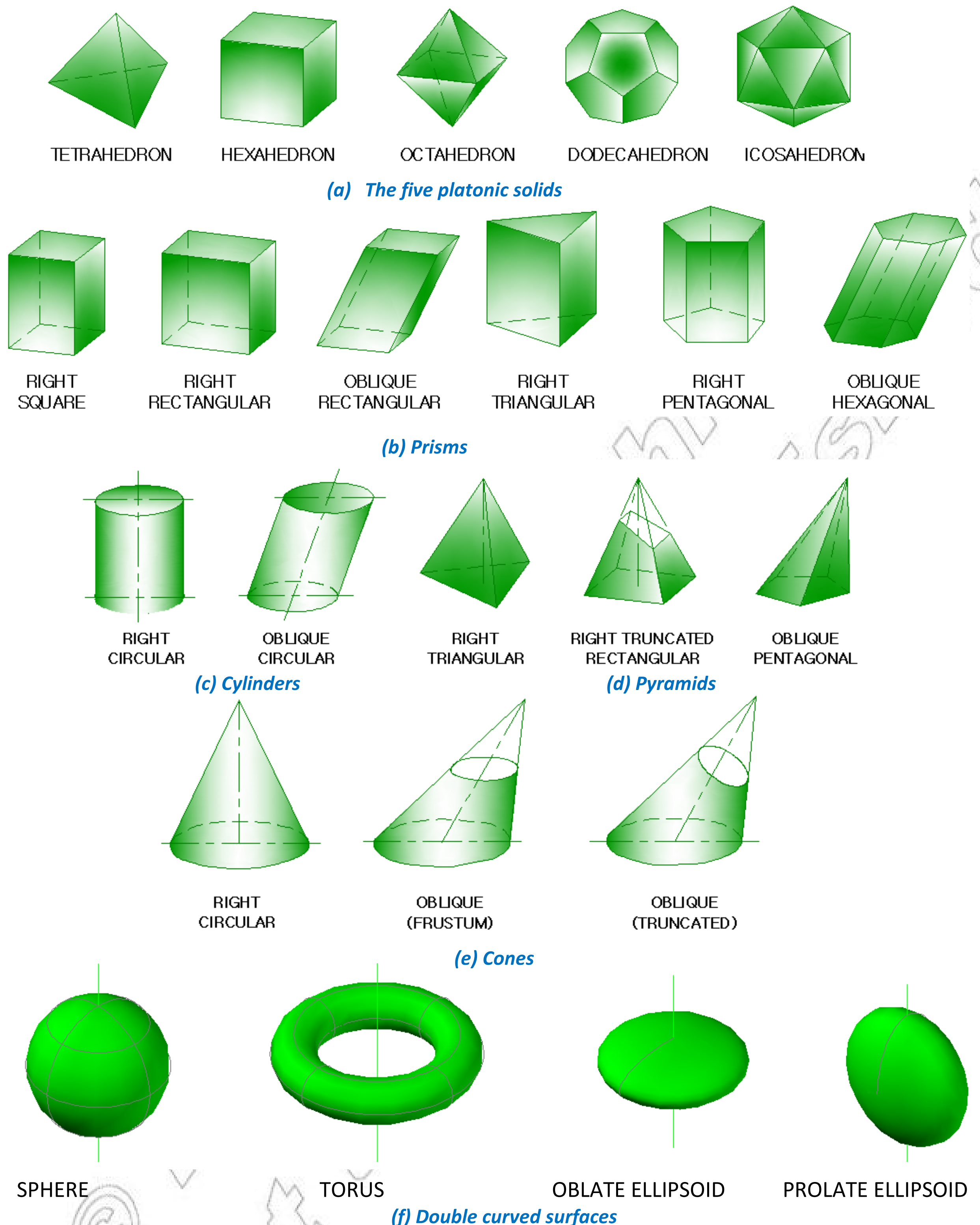


Fig. 5.1 Solids and surfaces which define the geometry of three-dimensional objects

There are three groups of solids. The first groups are solid that are bound by plane surfaces are called *polyhedra*. The common examples of polyhedra are the *prism* and *pyramid*. Those polyhedra whose faces are all equal regular polygons are called *regular polyhedra*. The five polyhedra are the *cube, tetrahedron, octahedrone, dodecahedron,* and *icosahedrons*. They are collectively known as the *five platonic solids* as shown in fig 5.1(a). Plane surfaces that bound polyhedra are called *faces* of the solids. Lines of intersection of faces are called *edges* of the solids.

The second groups are solids that may be generated by revolving a plane figure about an axis in the plane of the figure. They are called *solids of revolution*. These include solids bound by single curved line example cylinder and cone, or include solids bound by a double curved line example sphere, and torus.

The third groups are solids that are bounded by surfaces. These solids do not have group name.

5.2 Development

Have you ever seen a model of a building?
How do you think real objects with a shape cube or cone can be constructed with a model paper?

Development is a complete layout of all surfaces of a solid on a plane or flat object. A surface is said to be developable if it can be unfolded / unrolled to coincide with a plane. Surfaces of polyhedral and single-curved surfaces are developable. But warped surfaces and double curved surfaces are not developable they may be developed by approximately dividing them into developable sections.

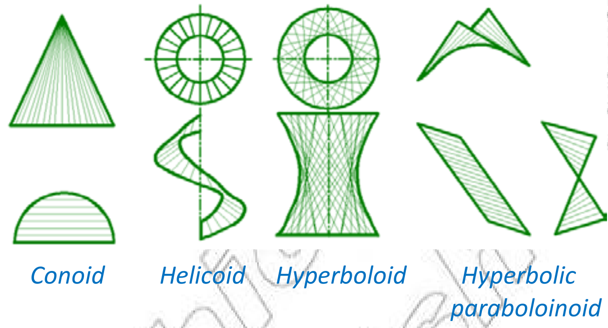


Fig. 5.2 Warped surfaces

In this unit, the development of the basic geometrical solids (Shapes) such as prism, cylinder, pyramid and cone is dealt by using the different methods of development to be discussed later on.

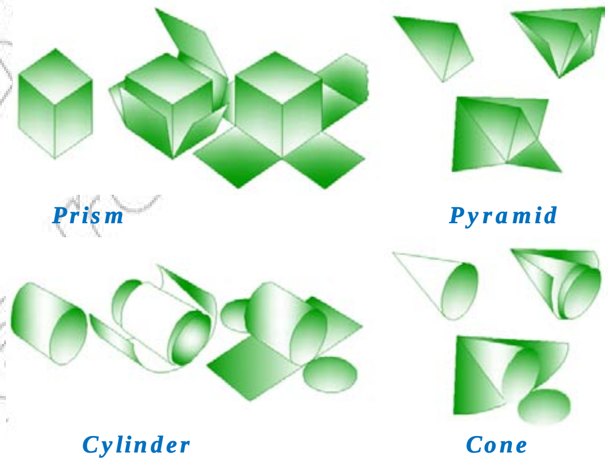


Fig. 5.3 Development of surfaces of solids

Practically the drawing operation consists of drawing the successive surface in their true size and shape with their common edges joined to each other.

Any professionally worker in a design and manufacturing industry is frequently required to have the knowledge of development of surfaces of an object. Practical application of development occurs for preparatory of packaging materials, cardboard and matc-hboxes, tin cans, funnels, cake pans, furnaces, pipes, elbows, ducts and roof gutters etc. made up of hard paper and sheet metal to be used as a container of various edible and nonedible item in a supermarket, to prepare many other house hold material and in many industries like automobile aircraft etc.

Principle of development

During making developments of surfaces, the following general rules should by observed.

1. Developments of solids are usually made with the inside surfaces up to facilitate bending or rolling during manufacturing.
2. It is possible to begin development of a solid from any edge desired, however it is a good practice to start and end with the shortest edge to provide strength of the final solid formed and ensure an economical usage of fixing material like UHU for paper models and soldering, welding and riveting for sheet metal model.
3. When making the development of a solid, elements should be labeled using numbers or alphabet of letters in the clock wise direction.
4. Bend or foldlines should be clearly shown in the development so that they will be used as guides for rolling or bending when making the final product.
5. Extra material to be used as lap or seam should be provided at the end element lines of the development where fixing or fastening is required. The amount of material to be added varies depending on the thickness of the material, the type of connection and production equipment.

Hem and joints for sheet metal works

Various types of hems and joints are used during manufacturing ducts, tanks, containers and other products from sheet metal. Hems are used to make the raw edge smooth and help to strengthen the material. Some of the more common types of hems and joints are shown below.

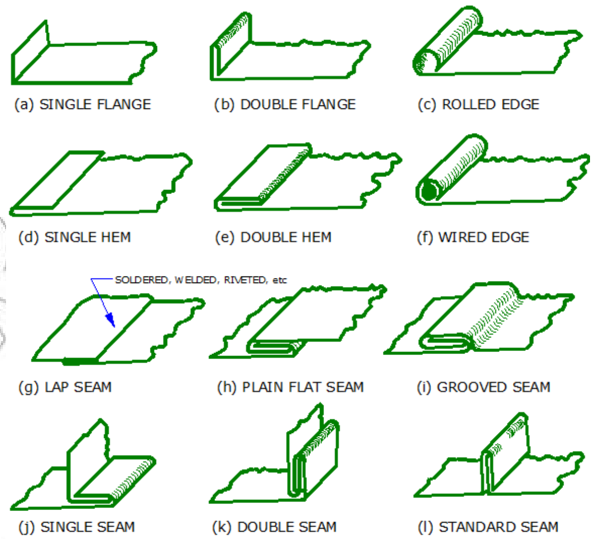


Fig. 5.4 Hems and joints used in sheet metal work

5.2.1 Methods of Development of Solids

- If you want to develop a cube and a cone, do you think that both of them can be developed with the same method?

There are three commonly known methods of developing solids based on their basic shapes like prism, cylinder, pyramid, cone and transition piece. However, only two of these methods are discussed in this text book.

5.2.1.1. Parallel Line Development

This method of development is used to develop shapes that are based on prism and cylinder by making use of stretch-out-line principle.

Note: All example of pattern development discussed in this unit do not include the extra materials to be used as a seam.

If the pattern development of a solid excludes the top and bottom cover, it is known as lateral surface development. But if it includes the top and bottom cover, it will become complete surface development.

A solid is said to be right solid if its axis is made perpendicular (90^0) to the base of the solid. Example are and Right prism, right cylinder. By default all solids are assumed to be right solid unless otherwise specified.

A solid is said to be oblique solid if its axis makes any acute angle with the base of the solid, Example are Oblique prism and oblique cylinder.

The term "*truncated*" is used in conjunction with some solids just to indicate that the solid has got an inclined or oblique surface formed after cutting it with a cutting plane at any assumed angle.

Checkpoint 5.1

a) Define three of the basic geometric element.
b) Write types of surfaces that are developable and non developable.
c) List three types of hems and joints.
d) What is development?
e) List the methods of pattern development you know.

Development of prism

Prism is a type of solid shape developed by parallel line method of development.

(A) To develop a full right square prism.

1) Draw the front and top views of the prism.
2) On the top view, number the edges in the clockwise direction so as to ensure the development will be made inside up. Also, number the edges on the front view in agreement with the numbering on the tip view.
3) Construct the stretch-out line 1-1 through the base of the front view.
4) Transfer the true width dimensions of the lateral faces of the solid from the top view on to the stretch out line sequentially to locate points 1, 2, 3, etc.
5) Draw perpendicular lines from the stretch-out line through 1, 2, 3 etc.

6) Transfer the true lengths of the edges of the prism from the front view using horizontal projection lines to the corresponding line on the development, to locate 1′,2′,3′, etc.

7) Complete the lateral surface development by joining the points so obtained at step 6. To prepare the complete surface development include the top and bottom faces (covers) as show in fig 5.5.

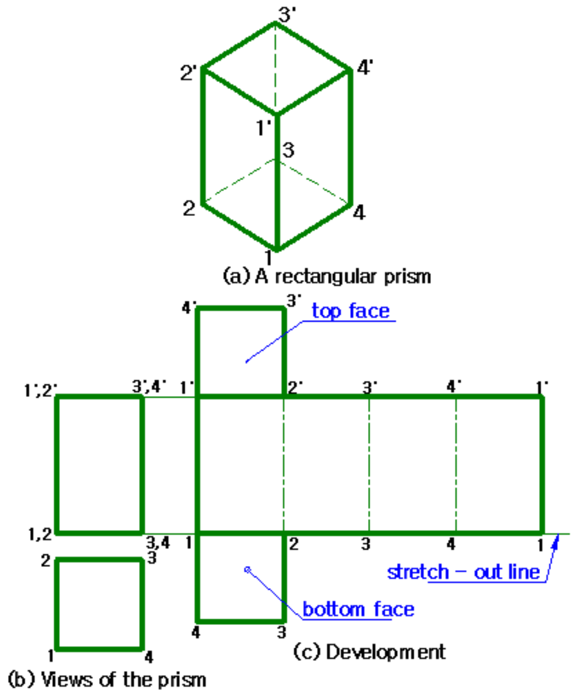


Fig. 5.5 Development of rectangular prism

Checkpoint 5.2

Prepare the pattern development of pentagonal prism whose height and one side length (face width) is 60mm and 20mm respectively.

(B) To develop a truncated square prism

1) Draw the front and top views of the prism.
2) Label (name) all the top corners in a clockwise direction, starting the development preferably from 1 the shortest edge. Also label all corresponding edges of front view with labeling made on top view.
3) Construct the stretch-out line 1-1 passing through the base of the front view.
4) Transfer the true width dimensions of the faces from the top view on to the stretch-out-line sequentially to locate points 1, 2, 3, etc.
5) Draw perpendicular lines to the stretch-out line through 1, 2, 3 etc.
6) Transfer the true heights of each vertical edges from the front view using horizontal projection lines onto the corresponding vertical lines of the development to locate 8',5',6', etc
7) To prepare the complete surface development include the true shape of the top cover which is obtained by an auxiliary view as discussed in unit 2 of this text book and the bottom cover of a right prism. See practical example on truncated right prism i.e. development of mail box.

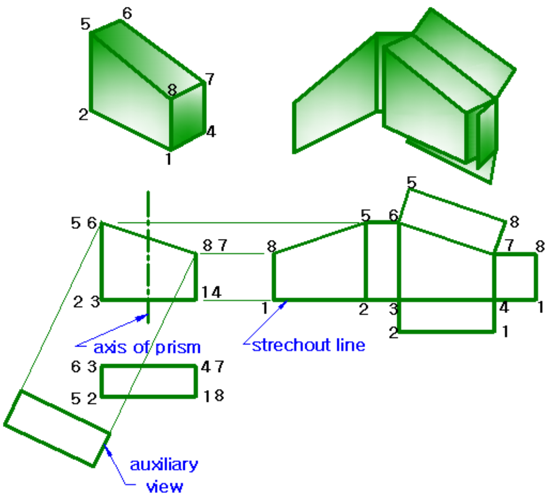


Fig. 5.6 Development of a truncated square prism

Checkpoint 5.3

Prepare the pattern development of a truncated hexagonal prism whose one side length is 15 mm and the longest and shortest vertical edges are 45mm and 25mm respectively.

To make the development of an oblique square prism

Use the same method as that of right prism except a difference that is the oblique prism development doesn't unfold in a straight line, so the stretch-out line is placed through the center of the prism.

1) Draw the front and top views of the prism.
2) Draw an auxiliary section that is perpendicular to the sides of the prism. The auxiliary section gives the true width of the sides.
3) Project the stretch-out line from the location of the auxiliary section. The stretch-out-line is projected from the front view.
4) Measure the true width of the faces along the stretch-out line as shown by points 1, 2, 3, and 4.
5) Draw lines through these points perpendicular to the stretch-out line to form the corners of the prism.
6) Project the end point of the corners to the development. This locates top and bottom ends of the corners.
7) Connect the corners to finish the development of the oblique prism.

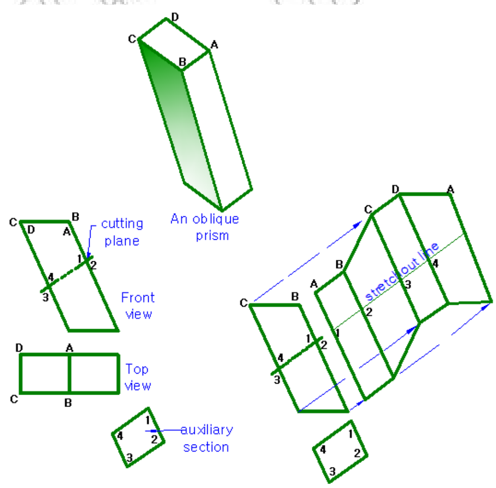


Fig. 5.7 Development of an oblique prism

Checkpoint 5.4

Prepare the development of full oblique octagonal prism whose axis is inclined at an angle of 450 and one side length is 20 mm.

Development of cylinder

Development is another type of solid developed by parallel-line method of development. Cylinder can be thought of as being a many sided prism. In this case the length of the stretch-out line is equal to the circumference of the cylinder. i.e c=2πr or 3D+1/7D where, c=circumference, 2= constant, π = 3.14, r= radius of the circle. The lateral surface development of a full right cylinder is a rectangle with length equal to the circumference of the base circular outline and width equal to the height of the cylinder.

Development of full Cylinder

To prepare the development of a right Cylinder

1) Draw the front and top view of the cylinder.
2) Divide the top circular view into any number of equal parts (Say 12).
3) Label each of the division points on the top circular view (1-12).
4) Draw the stretch-out line. On the left end, draw a perpendicular line. Make it the same length as the height of the cylinder.
5) Measure the straight line distance between two division points on the circular view (i.e. chordal length to approximate arc length).
6) Step off these distance on the stretch out line as many division as you have on top view to give circumference length or divide the circumference length (C=2πr) into same number of divisions you have on top view for more accurate surface development.
7) On the last division, draw a line perpendicular to the stretch-out line. Draw the top edges of the cylinder parallel to the stretch-out line.

This method of obtaining circumference is approximate. The distance used is chordal distances. A chord is shorter than its arc length. A more accurate method of obtaining circumference is using mathematics i.e. C = 2 πr.

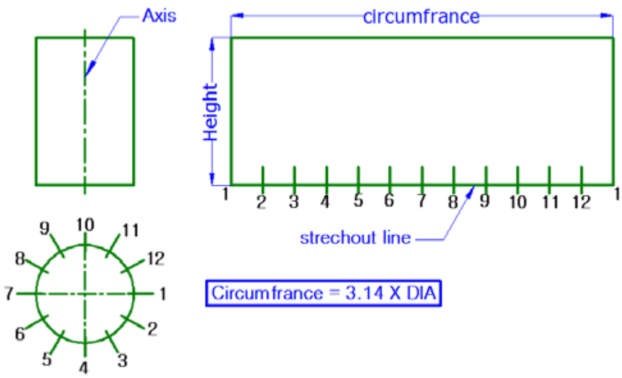


Fig. 5.8 Development of cylinder.

Development of truncated Cylinder

To prepare the pattern development of truncated cylinder

1) Draw the front and top views of the truncated Cylinder.
2) Divide the circular top view into any number of equal parts (say 12).
3) Project these points into the front view.
4) Draw the stretch-out line perpendicular to the axis of the Cylinder.

5) Measure the straight line distance between two division points on the circular view (i.e. the chordal length approximating the arc length.)

6) Step off these distance on the stretch out line(for approximate development) or divide the circumference length into the same number of divisions or sectors you have on top view (for relatively accurate development.)

7) Draw perpendicular lines through each point on the stretch-out line starting with shortest edge.

8) Project points from the top outline to edge view of the inclined surface on front view and then to the pattern development vertical edges so as to get the points to be joined with irregular curve.

9) For the complete surface development include the top and bottom surfaces. Here the tangent line is used to get the exact tangent point between the top cover and the lateral surface, the true shape of the top cover is obtain in auxiliary view.

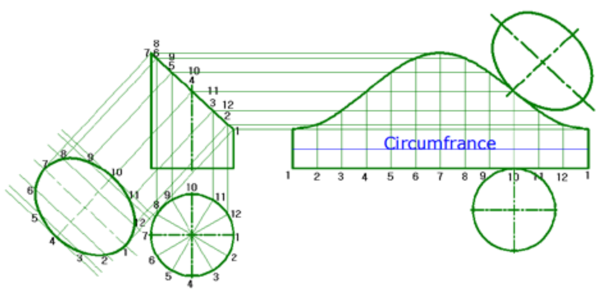
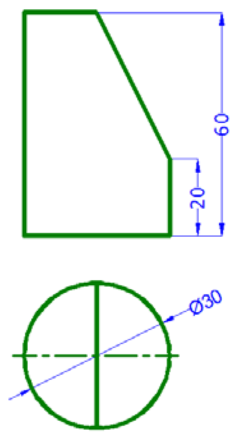


Figure 5.9 Development of truncated cylinder.

Checkpoint 5.5

Prepare the development of the given truncated cylinder.



Development of oblique cylinder

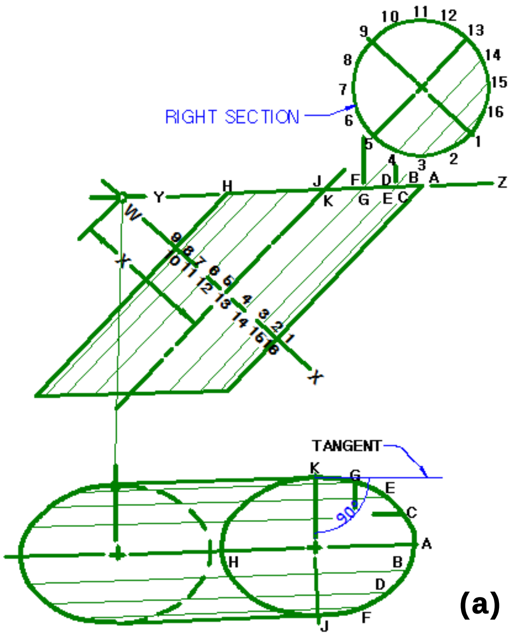
Since an oblique cylinder theoretically may be though of as a regular oblique prism with an infinite sides so the principle of development is more or less similar to that of oblique prism discussed earlier with minor variation.

To prepare the development of an oblique cylinder.

1) Draw the front and top view of the oblique Cylinder.
2) Draw the right auxiliary section.
3) Divide the right section into say example 16 equal parts to get 16 surface line elements and label them in all views.
4) Draw the stretch-out line w-x i.e. equal in length to the circumference of the right section circle.

5) Divide the stretch-out line into the same number of equal parts as in step 3 locating points 1, 2, 3, etc.
6) Draw lines perpendicular to the stretch-out line through points 1, 2, 3 ...etc.
7) Transfer the true length of each surface line elements from the front view to the pattern development to locate points A, B, C etc.
8) Draw smooth curve passing through point A, B, C... etc, using French curve.
9) Attach the top and bottom cover at the tangent points established or the development by using tangent line as shown on the figure below.

The top and bottom covers (i.e. ellipse) will be constructed by using major axis AH and minor axis KJ of the top view (use any ellipse construction method.)



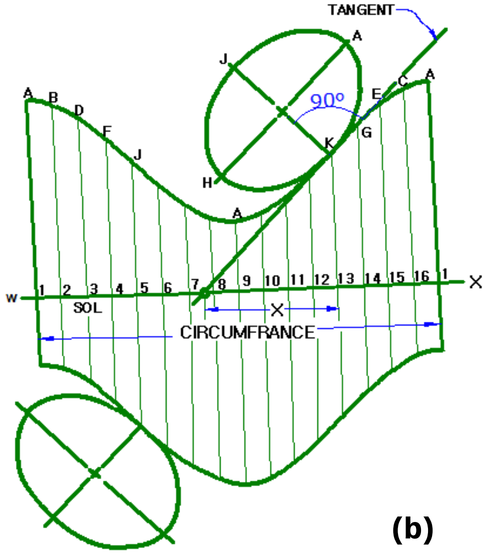


Fig. 5.10 Development of oblique cylinder

5.2.1.2. Radial-Line Development

This method of development is used to develop shapes that are based on pyramid and cone which have a series of lines which radiate from the apex down to the base of the object and requires the determination of true length of foreshortened lateral edges before attempting to prepare the development.

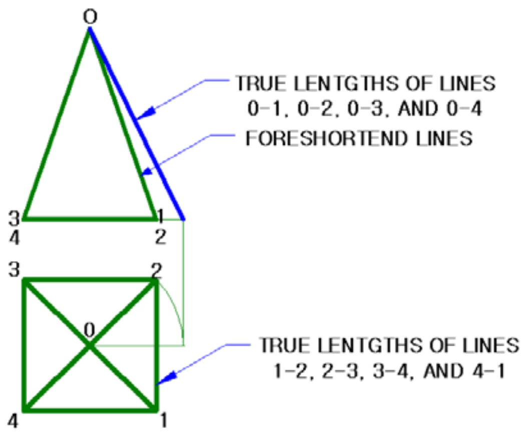
Development of right pyramid

A right pyramid is a pyramid having all the lateral edges from vertex to base of equal length.

In the process of developing a right pyramid, a large arc is made with radius equal to the true length of the lateral edge of the pyramid. Then, points are marked on this large arc using compass by setting off arcs with radius equal to the true lengths of the base sides of the pyramid. The true lengths of the edges of a pyramid are found by using the triangulation method.

To draw the development of full pyramid.

1) Draw the front and top view of the by pramid.
2) Label all corners on top view and front view as well.
3) Find the true length of edge (e.g. 0-1) using revolution or other method.
4) Draw a large arc with 0 as center and radius equal to the true length of edge 0-1 .
5) Drop a perpendicular (vertical) line from 0 so as to intersect the large arc and get 3 .
6) Start from 3 and step off the true distance 3-2, 2-1, 3-4 and 4-1, which are true lengths of base edges obtained from top view, along the large arc with compass.
7) Join these points with straight line to establish the base edges.
8) Finally join these points (i.e. 1, 2, 3, 4 and 1) to the vertex point to represent folding edges of the solid.



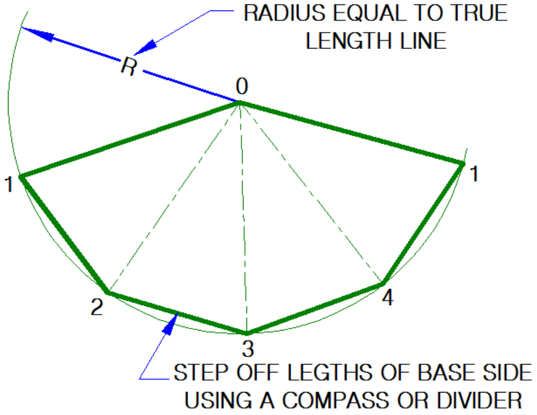


Fig. 5.11 Development of right pyramid.

Checkpoint 5.6

Draw the complete surface development of hexagonal pyramid if one base side length and the altitude are 20 and 50mm respectively.

Development of truncated right pyramid

If a full right pyramid is cut with a cutting plane at a convenient angle other than 90° with the axis the remaining pyramid is called truncated right pyramid and if it is cut perpendicular or at 90^0 angle with the axis. It is called frustum pyramid.

The procedure of development is the same as the full pyramid except that only the truncated edge lines are required.

To draw the development of truncated pyramid.

1) Draw the front and top view of the truncated pyramid.

2) Label all corners on top view and front view as well.

3) Find true length of the full lateral edge of the pyramid on the front view by first revolving line 0-1 of the top view to intersect horizontal center line passing through apex 0 at 1^1 and then project up 1^1 and to front view to intersect the extended base line at 1′, and finally join 0 with 1^1 of front view.

4) Find the true length of the truncated lateral edges (A-l and B-2, C-3 and D-4) on front view by projecting horizontal line from AB and DC to true length edge 01^1.

   Now line E-1′, is the true length of edge C-3 and D-4. Line F-1′, is the true length of edge A-1 and B-2.

5) Draw a large arc with 0 as center and radius equal to the true length edge 0-1′ as shown on front view on a blank space.

6) Drop perpendicular/vertical line from 0 so as to intersect the large arc and establish 3.

7) Start from 3 and step off the true distance 3-2, 2-1, 3-4 and 4-1 from the top view using compass to get the remaining point 1,2 and 4 along the large arc.

8) Join the points located on the large arc with straight line to establish the true base edges on the development.

9) Connect points 1,2,3,4 of the large arc with the apex ‘0’.

10) Transfer the true lengths of each edges (E-1′ and F-1′,) for the corresponding edge length along lines established at step 8 to get A,B,C,D and A.

11) Let us connect the top cover of the truncated pyramid to edge A-B of the development. To do so first use B as center and true edge length B-C of the development as a radius and strike an arc. Use A as a center and true distance of A-C as a radius as shown to the left of front view and strike another arc so as to intersect the previously drawn arc and establish ‘C’ of top cover. Use A as a center and true distance A-D of the development as a radius and strike an arc.

    Use B as a center and true distance of B-D(equal in length to A-C) as a radius and strike another so as to intersect arc drawn at previous step and establish “D” of the top cover . Join points A, D, C and B to complete the top cover.

Note: You can first draw the true shape of the inclined surface by auxiliary view method and use two of the corners as center and the diagonal distance as a radius accordingly as discussed above to establish the remaining two corners and complete the top cover.

To attach the bottom cover on the development.

i. Select one of the base edges upon which to connect the bottom cover.

ii. Draw perpendicular lines through the end points of the edge selected to the direction the cover is drawn.

iii. Transfer the true adjacent base edge lengths along these perpendicular lines.

iv. Connect the points obtained along these perpendicular lines at step III with straight line parallel to the initial base edge selected.

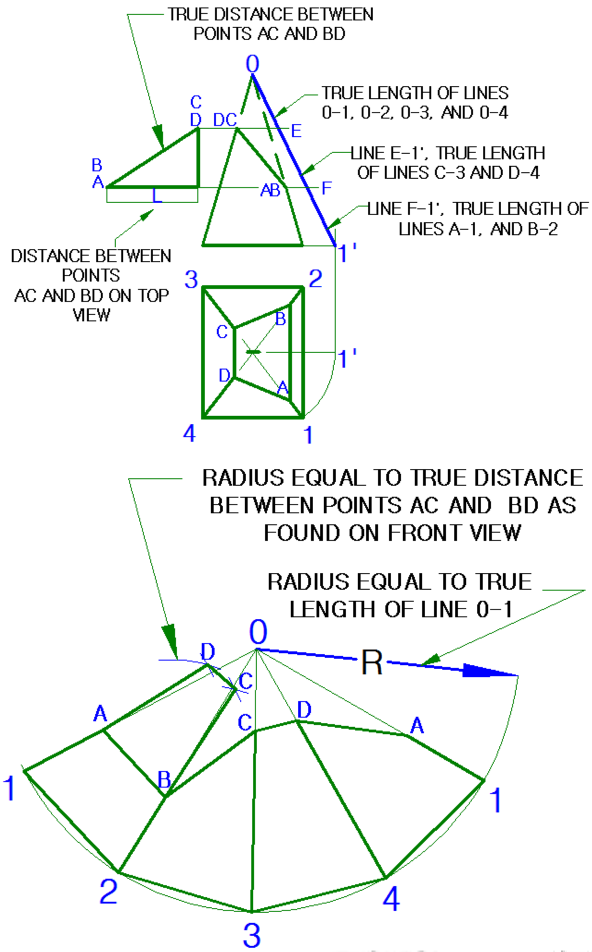
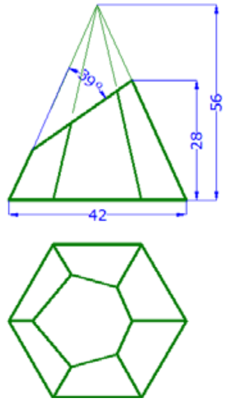


Fig. 5.12 Development of truncated pyramid

Checkpoint 5.7

Prepare the complete surface development of the following trun-cated hexagonal pyramid shown below



Development of oblique pyramid

Oblique pyramid is a pyramid having its axis at an angle other than 90⁰ with the base of the solids, so that paired or all lateral edges have unequal lengths. So the true length of these edges should be found as shown in Fig.5.13.

To prepare the development of full hexagonal oblique pyramid.

1) Draw the front and top views of the oblique pyramid (Fig.5.93).

2) Label the edges of the pyramid on both top and front views.

3) Construct the true length diagram that shows the true length of all lateral edges on the front view.

4) Start the development by first drawing line 0_F 1_r (the shortest edge) from the true length diagram.

5) With 0_F as center and radius $0_F\ 2_r$ drawn an arc and adjust your compass with side 1-2 as radius from top view and draw another arc to intersect the first arc drawn at 2.

6) In a similar manner locate the other points i.e 3, 4, 5, 6.

7) Join points 1, 2, 3, 4, 5 and 6 to each other and to point 0. Also attach the base with the same procedure discussed on right pyramid to make the development complete.

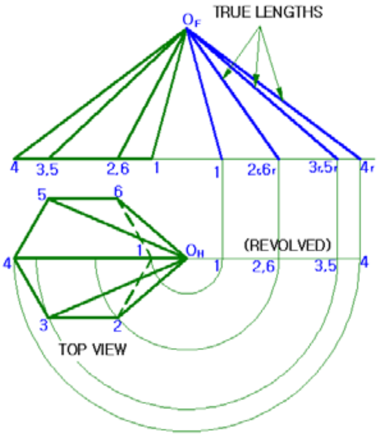


Fig. 5.13 True length diagram

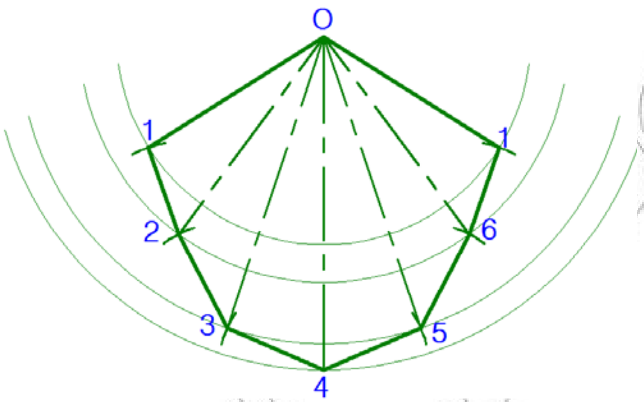
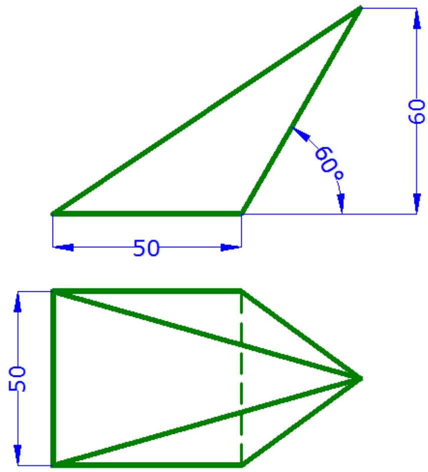


Fig. 5.14 Development of oblique pyramid.

Checkpoint 5.8

Prepare the development of the given square oblique pyramid



Development of truncated oblique pyramid

The procedure of finding the true length of the truncated edges is similar to that of truncated right shown discussed earlier. The method and procedures of surface development is also similar to that of full oblique pyramid (See Fig. 5.15).

Key terms

- ***Frustum:*** is a section of a conical shape.
- ***Pattern making:*** is the process of creating a 2D map of a 3D shape to be formed.
- ***Patterns:*** are two dimensional maps of three dimensional shapes.
- ***Radial lines:*** are the development lines used to construct a pattern for a shape. Also known as radial guidelines.

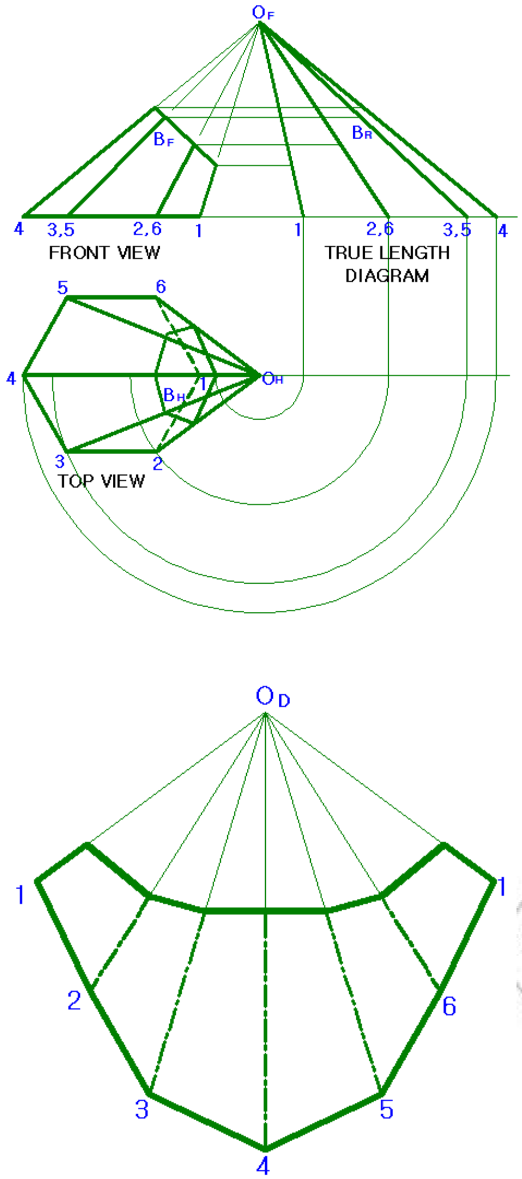


Fig. 5.15 Development of truncated oblique pyramid.

Development of cone

The development of a cone is similar to that of pyramid, use the radial line method of development. The cone is thought of as a many sided pyramid.

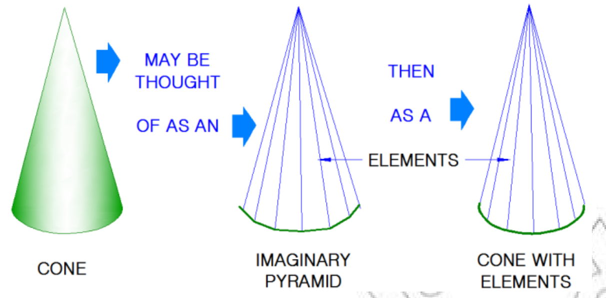


Fig. 5.16 Development of cone.

The development of a right full cone is simply a sector whose radius is equal to the slant height (hypotenuse) of the cone and whose arc length is equal to the circumference of the base of the cone. The subtended angle can be found using the following formula.

$$Ø = \frac{r}{s} \times 360^0$$

Where: r- is the radius of the base circle of the cone and s is the slant height (hypotenuse) of the cone.

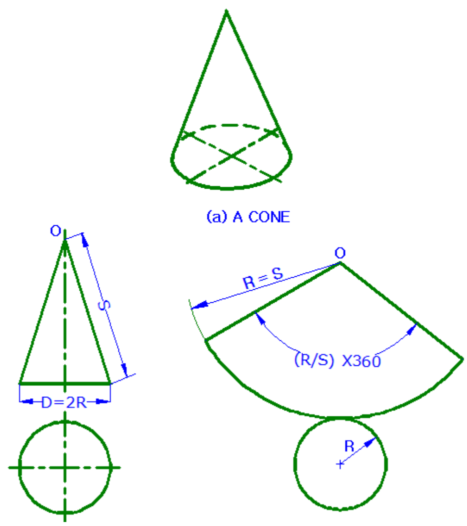
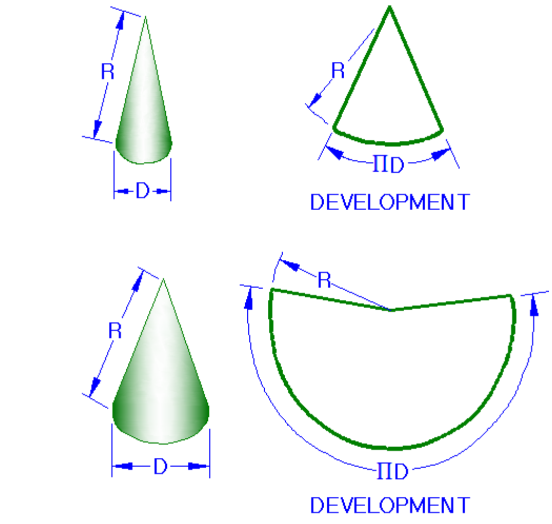
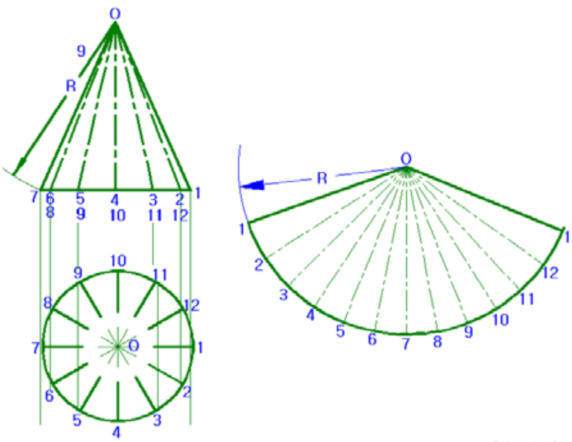


Fig. 5.17 Development of right cone

The proportion of the height to the base diameter determines the size of the sector as shown on Fig.5.18.



(A) PROPORTION OF HEIGHT TO BASE



(B) DEVELOPMENT PROCEDURE

Fig. 5.18 Development of right cone

Steps to draw the development of a cone

1) Draw the front and top view of the full right cone.

2) Divide the top view into a convenient number of equal divisions in this instant into 12.

3) Label all division points on top view and their corresponding points on front view.

4) Draw a large arc on the development using 0 as a center and true length edge 0-1 (0-7) of front view as radius.

5) Take a single chordal length of the top view to approximate the arc length with compass and step off along the large arc equal divisions as you have on top view.

6) Join the end point of the large arc to apex '0' to complete the lateral surface development.

> ***Note:*** You can also attach the bottom cover taking its true shape from top view.

To draw development of frustum of a cone.

Draw the development of the full cone as shown in Fig 5.18.

1) Draw an arc on the development of the cone with O as center and OA as radius to locate the top edge of the frustum. (Fig.5.19).

2) Include the top and bottom cover obtained from top view to make the pattern development complete.

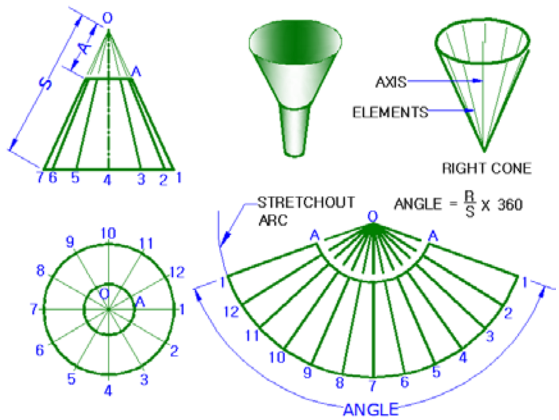


Fig. 5.19 Development of frustum of a cone

Development of truncated right cone

The development of truncated right cone is similar to the development of full cone except minor difference resulting from the truncated element lines.

Before preparing the pattern development of a truncated right cone, the top view of the truncate part (i.e. the ellipse) and its true shape should be complete and found respectively.

To complete the top view truncate part (ellipse) of the cone

1) Draw the front and top view of the truncated cone with its apex '0'
2) Divide the top view into any convenient number of equally spaced element line say 12 then label them in a clockwise direction.
3) Project these element lines from top view to the base of front view and then to the apex '0' so as to get points a, b, c etc on the edge view of the ellipse.
4) Project points a, b, c, etc from front view back to top view on the corresponding elements lines to get points a′, b′, c′ etc
5) Draw smooth curve through points a′ b′, c′ etc to complete the top view of the ellipse.
6) Draw the true shape of the ellipse using auxiliary view method to help complete the pattern development.

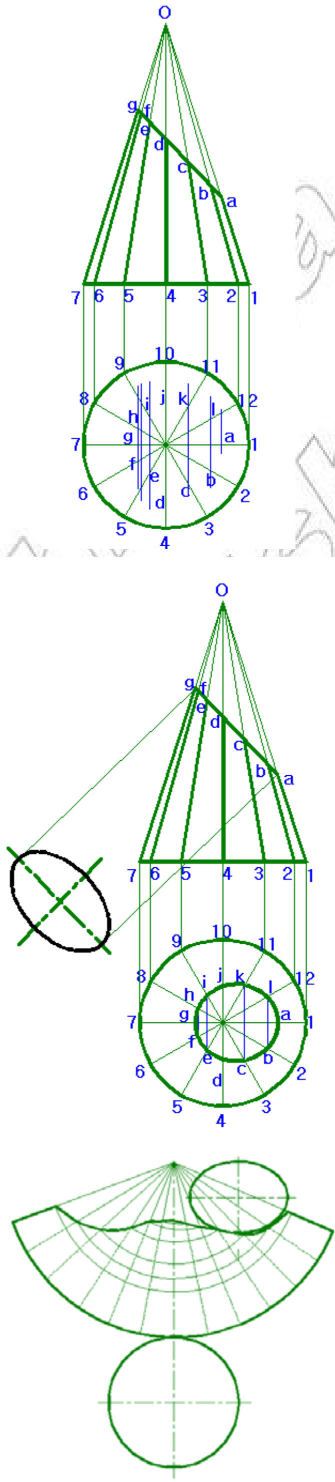
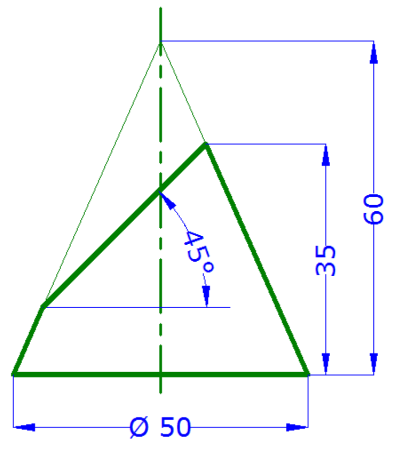


Fig. 5.20 Development of truncated cone.

7) Project points a, b, c, etc from the edge view of the ellipse to the true length line 0-1 of front view to get the true lengths of all other element lines.
8) Draw the development of the full cone as discussed earlier.
9) Transfer the true length of all element lines (eg.0-a, 0-b, 0-c etc) from front view to the corresponding element lines of the development to locate points a, b, c, etc
10) Draw smooth curve through points a, b, c, etc obtained on the development and attach the base and the top elliptical surface to complete the development.

Checkpoint 5.9

Prepare the development of the following truncated cone.



Development of oblique cone

Oblique cone can have either a circular or elliptical base as shown on Fig.5.21, either type can be developed approximately. The development of an oblique cone may be made in a manner similar to the development of an oblique pyramid by considering the cone as a pyramid with infinite number of edges however here finite number of edges (i.e. 12 element lines) are used.

To prepare development of oblique cone

1) Draw the front and top views of the oblique cone.
2) Divide the circular view of top view into any number of equal parts (say 12).
3) Label the points in a clockwise direction starting from 1 as shown on figure. 5.21 and connect them to apex 0 to establish elements lines on top view.
4) Project point 1, 2, 3, etc from top view to the base edge of front view and label them accordingly.
5) Draw the element lines from each base edge points to apex '0' of the front view. This divides the lateral surface into series of triangles.
6) Construct the true length diagram that shows the true length of all element except 0-1 and 0-7 which appeared as true length on front view by revolution method
7) Make the development by laying out the triangles in the order they are found on the views of the cone. Start with the 1st triangle 0-1-2

First layout true length side 0-1. All radiuses for other lateral elements and arc length are taken from true length diagram and top view respectively. Draw an arc using 0 as a center and 0-2 as a radius. Draw another arc with 1 as center and 1-2 as radius to intersect the first arc drawn and establish 2 on the development. Again draw an arc using 0 as a center and 0-3 as a radius. Draw another arc with 2-3 as a radius to intersect the previous arc drawn and establish 3 on the development.

8) Repeat these steps for each element until all points on the development are shown.
9) Draw a smooth curve through points 1, 2, 3 etc using French curve. You can also attach the base to complete the development.

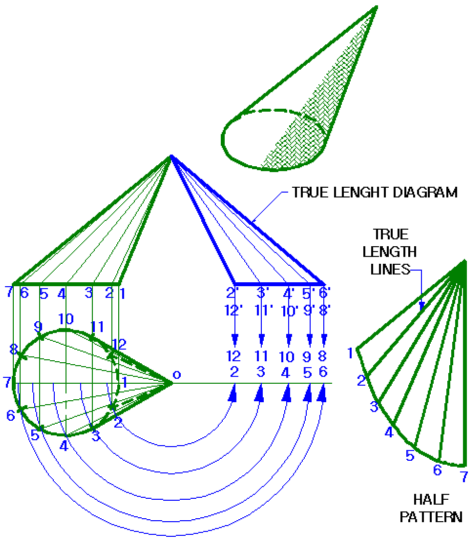


Fig. 5.21 Development of oblique cone.

Development of truncated oblique cone.

The procedures of finding the true length of the truncated edges is similar to that of truncated oblique pyramid and other procedures of development construction is Similar to that of oblique cone.

5.3 Intersection Between Geometrical Solids

List the geometrical solids you know.
Imagine when some of the solids intersecting and make an intersection line or curve between them.

A thorough knowledge of this subject would help greatly a student of engineering or an engineer engaged in his/her practical field.

A machine part of any kind normally may be assumed to consist of a number of geometric shapes arranged to produce the desired form. The common intersecting geometric shapes in sheet metal work like prism, cylinder, pyramid and cone may sometimes be combined or interlocked in a pattern that is easily represented. However in this text only intersection of solids based on prism and cylinder is discussed. In sheet metal work, the line of intersection between intersecting or penetrating solids will have to be found out before the development of the solids is prepared. The principles of intersection have many more practical applications in making of ducts, pipe joints, containers, fitting of a steam dome on cylindrical boiler, cutting of openings in roof surface for flues and stacks, etc. can be mentioned.

Classification of surface intersection

A) Intersection of two solids with plane surfaces (Example intersection of prism and pyramid). The common intersection outline becomes a straight line so it is called as line of intersection.

B) Intersection of two solids one with plane surface and the other with curved surface (Example intersection of prism and cylinder). When they intersect each other the common intersection outline in majority case becomes curve, but sometimes partially line and partially curve depending on the shape, size and orientation of the solids under intersection.

C) Intersection of two solids bounded by curved surfaces. (Example intersection cylinder and cone). When they intersect each other, the common intersection outline becomes a curve so it is called as curve of intersection and the manufacturing of which will directly depends on the development of solids intersected.

5.3.1. Piercing point

Bring a paper and pierce it with your pen or pencil and observe the exact contact point of the pen and the paper.

Before trying to determine the line or curve of intersection resulting from intersection or penetrating solids, we must be able to determine a piercing point.

Piercing point is the point of intersection of a line and a plane. The line can represent the lateral edge of a plane solid or the element of a curved solid. The plane can represent the surface of a solid.

A number of piercing points so located by the intersection of the edge or elements of one solid with the plane or surface of another intersecting solid will be joined to each other using set square or French curve to establish the required line or curve of intersection.

Finding piercing point resulted from intersection of line EG and triangular plane ABC (Fig 5.22).

Note: Line ED can represent the lateral edge of one of intersecting element and plane ABC, the lateral surface of another intersecting element.

The piercing point is obtained by assuming a cutting plane (Containing line EG and at the same time passing through the triangular plane ABC using the two given views of the line and plane.

Steps to find the piercing point

1) Draw the front and top views of the two intersection elements (line and plane).
2) Label the line as EG and the plane as ABC.
3) Introduce any convenient cutting plane containing line EG. A cutting plane perpendicular to one of the principal plane (in this case horizontal plane) is convenient because it appears as an edge (line) view in a principal view (i.e. top view.)
4) The line of intersection 1-2 is determined by the intersection of plane ABC and the assumed cutting plane.
5) Since line EG and line of intersection 1-2 both lie in the same cutting plane, they intersect each other to locate point "P".
6) Since line of intersection 1-2 also lies in plane ABC, point 'P' is now the required piercing point under the intersection of line EG and plane ABC.

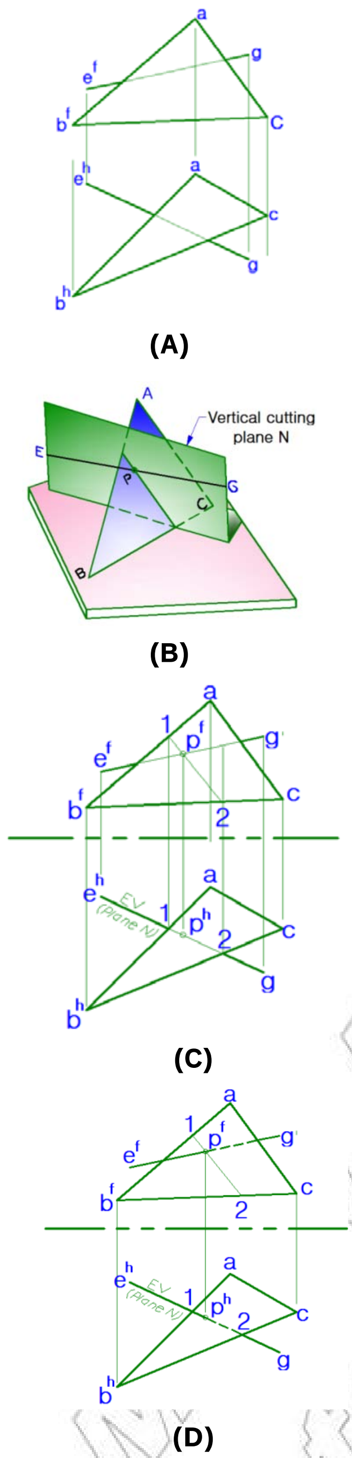


Fig. 5.22 Finding piercing point of a line and a plane intersecting.

5.3.2. Methods of Locating Point of Intersection.

There are two commonly known methods of locating point of intersection between intersecting solids.

1) End view method
2) Cutting plane method

1) End view method

This method is commonly used to find the line of intersection between intersecting solids with plane surfaces.

Begin by labeling the corners/vertices of a plane figure or surface of one of the intersecting solids on end view.

Note: The plane figure/surface labeled on the end view represents the edge view of the lateral surface and the labels show the point view of the lateral edges along which the line of intersection lies.

2) Cutting plane method

This method is used to find the line of intersection between intersecting solids with both plane and curved surfaces, so it is preferable for curved surfaces.

Pass a series of imaginary cutting planes as required through both solids under intersection used to locate points on the line/curve of intersection, resulted from intersection of cutting planes with edge view of the lateral surface of both solids on the views.

5.3.3. Intersection of two Regular Prisms and their Development.

The intersection of two prisms is found by locating the piercing points of the edges of one solid on the surface of the other solid using end view (side view) method.

Steps to find the line of intersection of the two intersecting solids (Fig.2.23).

1) Draw the front and top views of both prisms.
2) Label the corners of the end view of the horizontal prism in a clock wise direction as shown by a, b, c and d along which the piercing points lie.
3) Project points a, b, c and d from end view to top view to intersect the edge view of the lateral surface of vertical prism along which piercing points again lie.
4) Project the same points a, b, c and d from top view down to front view to intersect the projection lines of corresponding points from end view and establish the required piercing points that lie on the line of intersection.
5) Connect the piercing points obtained at step 4 to complete the line of intersection of the two intersecting prisms.

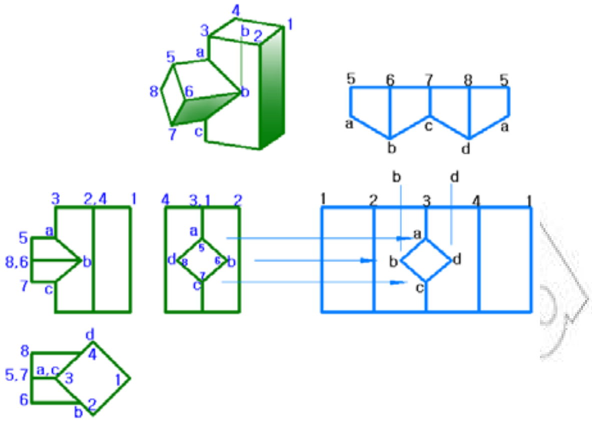


Fig. 5.23 Finding line of intersection of two intersecting prisms.

Steps to prepare the lateral surface development of the vertical prism.

We are using parallel-line method of development as the solid to be developed is a prism. So follow the basic procedures to be used for this method as discussed earlier.

1) Draw the top and front views of the prism. (As already shown)
2) Label all the top corners of the prism in a clockwise direction as (1, 2, 3, and 4) also show corresponding labeling on front view.
3) Draw the stretch-out base line passing through the base of the front view.
4) Transfer the true length edges of the top view 1-2, 2-3, 3-4 and 4-1 along the stretch out line and label them.
5) Draw perpendicular lines through labeled points of the stretch-out line to establish the various lateral edge heights.
6) Project the piercing points (a, b, c and d) from front view onto the development to intersect corresponding lateral/vertical

edges and establish the line of intersection.

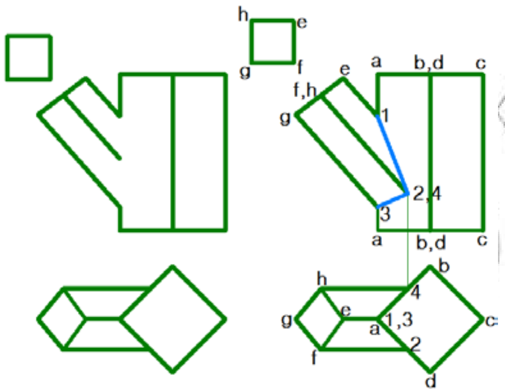
i.e. points a and c lie on lateral edge 3 where as points b and d lie on assumed lateral edges whose true distance can be measure from edge 3 of top view and transferred along the stretchout line each side.

5) Connect the piercing points so obtained at step 6 to complete the line of intersection on the development.

To develop the small horizontal prism follow the same steps as the vertical prism provided that the true length edges to be transfer along the stretch out line are obtained from end/side view i.e. 5-6, 6-7, 7-8 & 8-5 and the true heights of the lateral edges are obtained either from front view or top view to get piercing points a,b,c and d finally connect these points to complete the corresponding line of intersection on this prism.

Intersection of two prism at an angle different from 90°.

The step to find the line of intersection is more or less similar to the previous case.



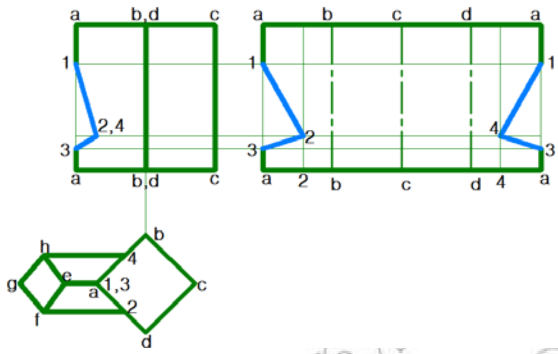


Fig.5.24 Finding line of intersection between intersecting prism at an angle and their development

If the axis of the two intersecting solids intersect at right angle or other angle regardless of their sizes and orientation we will obtain a visible line of intersection on the front view. However the possibility of getting hidden and visible line of intersection is high under the following conditions: If the axis of the intersecting solids do not intersect or apart each other by some distance, If the shapes of the solids under intersection are different and If different arrangement/orientation is used than a regular arrangement.

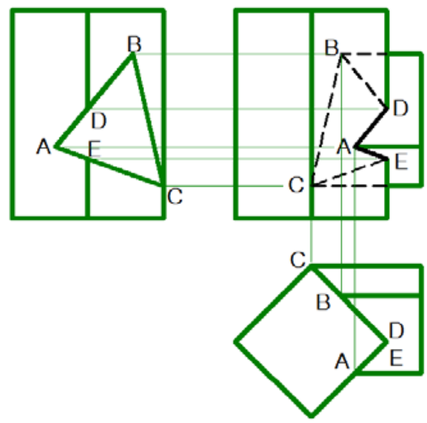
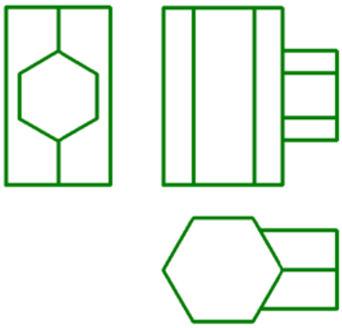


Fig.5.25 Visible and hidden line of intersection of intersecting prisms.

So you see that on front view of Fig.5.25 line DA and AE are visible line of intersection, where as line BD, BC, CE are Invisible/hidden line of intersection.

Checkpoint 5.10

Find the line of intersection created between the following intersecting solids and prepare the lateral surface development of both solids.



5.3.4. Intersection of two Cylinders and their Development.

The curve of intersection of two intersecting cylinders is found by using a series of cutting planes. So we are using cutting plane method.

Steps to find the curve of intersection of two intersecting cylinders at right angle (Fig 5.26).

1) Draw the front and top views of both cylinders and circular view of the horizontal cylinder on the front or side view is required.
2) Pass a required number of vertical cutting planes through both the cylinders by the following two options.
   i. By dividing the circular view of the horizontal cylinder into say 12 equal parts on side view or draw elements along which the cutting planes are assumed to pass through
   ii. By dividing the edge of the horizontal cylinder on top view into defined number of equal parts. Including the center line as marked as A,B,C,D.
3) Label all the points established by the intersection of the circular view with cutting planes both on top view (i.e. 1,2,3,4,5,6 and 7) front view (i.e. A,B,C,D) where only half view of the circle is used.
4) Project points established at step 3 from top view of vertical cylinder and end view of horizontal cylinder to the front view to get corresponding intersection points.
5) Connect intersection points obtained at step 4 with French curve so as to get the required curve of intersection.

Steps to prepare the lateral surface development of the vertical cylinder (Fig 5.26)

As discussed earlier parallel line method of development is used to develop the cylinder.

1) Draw the front and top views of both cylinders. As discussed already.
2) Draw the stretch out line passing through the base of the front view whose length is equal to the circumf-erence length of the large circle of top view.

3) The total height drawn perpendicular to the stretch-out line is directly projected from the front view.

4) Draw the center line perpendicular and passing through the mid point of the stretch-out line.

5) Draw the other lines representing the cutting plane parallel to the center line and through points 1, 2, 3 etc located by taking the chordal lengths X,Y, etc. from top view onto the development.

6) Project the points of intersection from the curve of intersection of front view to the corresponding cutting plane lines to get another intersection points on the development.

7) Connect these points with French curve to complete the shape of the opening into which the small cylinder fits.

The lateral surface development of the small horizontal cylinder can be made in a manner similar to the development of truncated cylinder.

Key terms

Stretch out: is two dimension patterns of a three dimensional object.

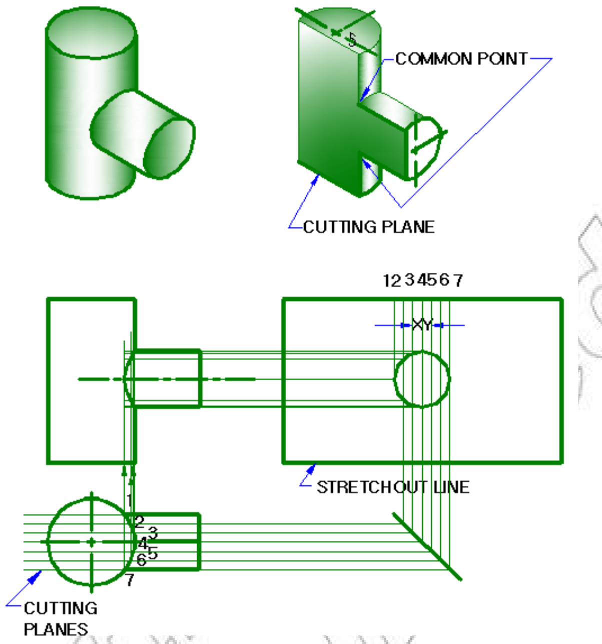


Fig. 5.26 Finding the curve of intersection and development of intersecting cylinders at right angle.

Steps to find the curve of intersection of two intersecting cylinders at an angle (Fig.5.27 (A)).

1) Draw the front and top views of both cylinders under intersection.

2) Draw the auxiliary view of the intersecting cylinder at an angle as half/full circle and divide it into equal parts to establish surface line elements on its lateral surface.

3) Label these points and project them to corresponding elliptical outline on top view.

4) Project all the points from the elliptical outline to circle representing the edge view of the vertical cylinder on top view.

5) Project points from circular view of top view to front view to intersect corresponding surface line element of the intersecting cylinder at an angle.

6) Connect points obtained at step 5 to complete the required curve of intersection.

To develop the lateral surface of the vertical cylinder (Fig. 5.27(B)).

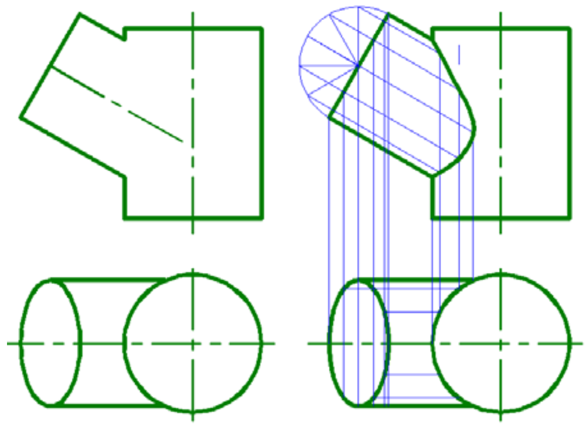
1) First draw the development of the full cylinder as discussed earlier.

2) Consider appropriate number of surface line elements on the cut portion of the cylinder then draw these elements on the development by transferring the spacing between them from the top view to the development.

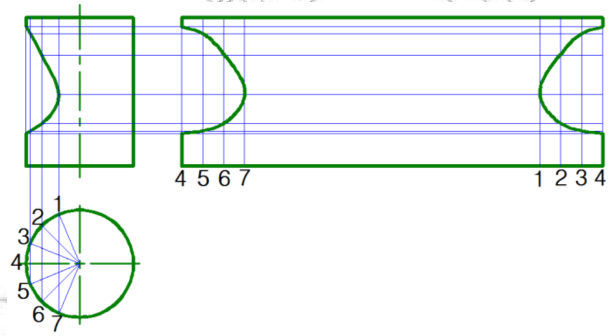
3) Transfer the lengths of these elements from the front view to the development to locate points on the line of intersection.

4) Connect the points so obtained in step 3 to complete the curve of intersection on the development.

The lateral surface development of the cylinder intersected at an angle can be drawn in a similar manner to the development of truncated cylinder.



(A) Intersection of two cylinders



(B) Development of the lateral surface of the vertical cylinder

Fig. 5.27 cylinder intersect at an angle

Key terms

Truncate: to cut the top of a shape along a plane that is not parallel to the base.

Checkpoint 5.11

Find the line of intersection and prepare their lateral surfaces' development of two intersecting cylinders at right angle. The diameter and length of the horizontal cylinder are 50mm and 80mm, respectively. The diameter and height of the vertical cylinder are 40mm and 80mm, respe-ctively.

Unit Summary

A layout of the complete surface of an object is called a development or pattern. If we wanted to make an object such as a cone, prism or pyramid a development may firstly be required. The development shows the true sizes of the surface of the object. A development should be drawn with the inside face up.

In prism development a development of only the sides of an object without the top or base is called a lateral development. With the top and bottom surfaces included it is called a full development. The true lengths of the lines must always be determined.

In the development of a cylinder firstly divide the circumference into elements. Then use the true length of these elements in the development.

While developing a pyramid first determine the true lengths of the edges and base.

Transition Pieces are pieces that change from one shape to another. So to develop a rectangular transition piece: the true lengths of lines must be determined. Lines that are not parallel to the frontal plane in the top view are not true length in the front view.

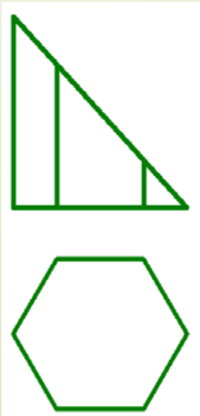
We can develop a transition piece that connects two circular pipes by stepping of the distance between points in the top view and using the height of the lines in the front view, the true length of the lines can be determined.
Intersection of two cylinders is possible by projecting data points in the top view down to the front view, obtaining both the height and width of the position of the points, the complete intersection of the two solids can be obtained.

For the Intersection of a cone and cylinder: The cone base must be divided into sections and then projection lines are projected up to the vertex of the cone. The intersection points can then be established on these projection lines by projecting from the front view.

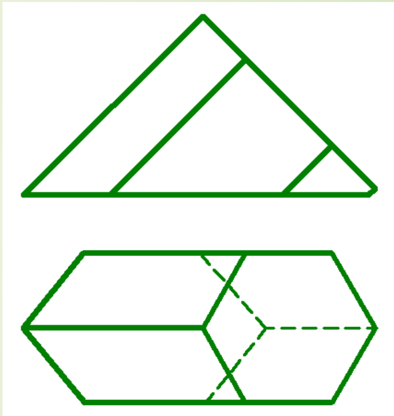
Exercise

EXERCISE I

Prepare the complete surface development of the following shapes.



(A)



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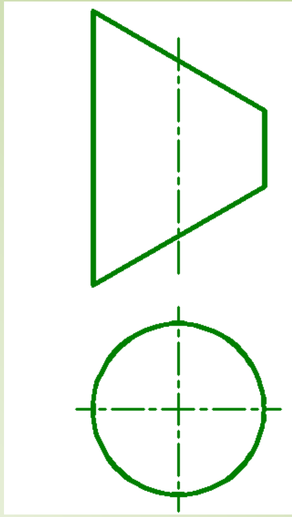
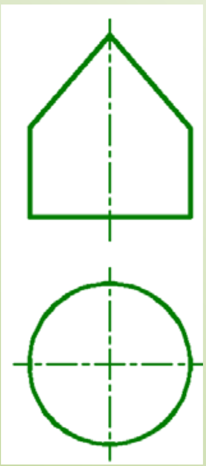


(C)



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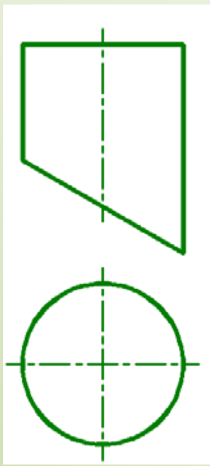

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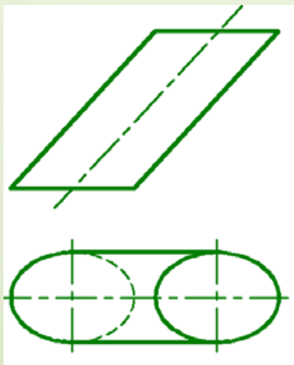

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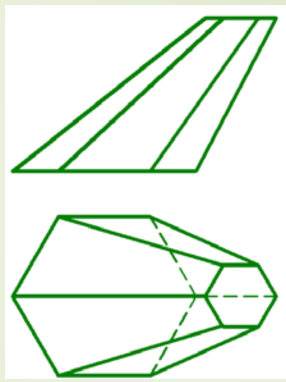
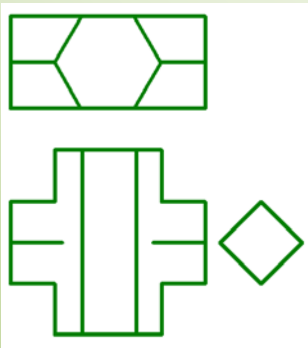


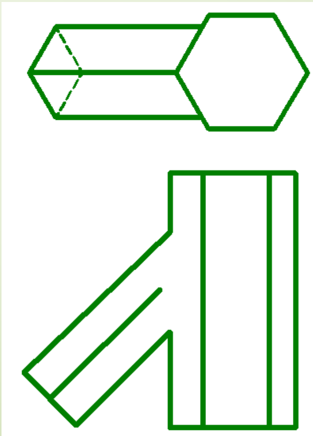
(G)

EXERCISE II

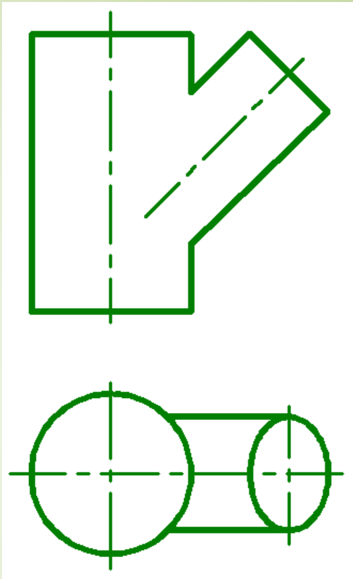
Find the line of intersection and then prepare the lateral surface development of the following intersecting solids.



(H)



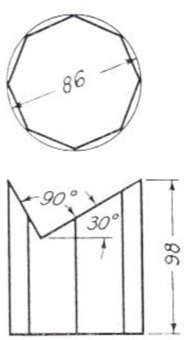
(I)



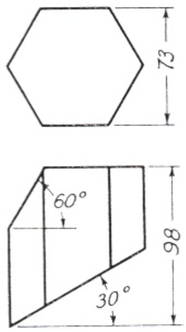
(J)

Project:

Develop the lateral surface with the upper and lower cover of the given drawing



(1)



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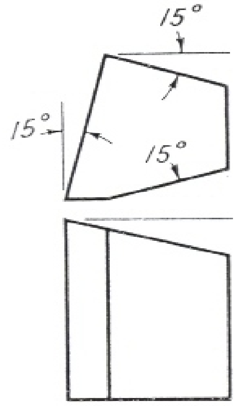

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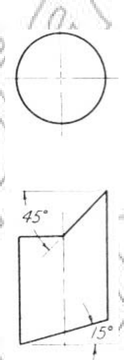

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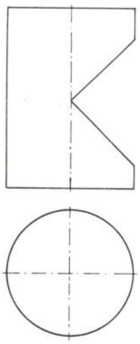

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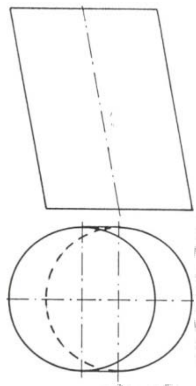

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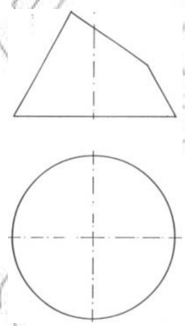

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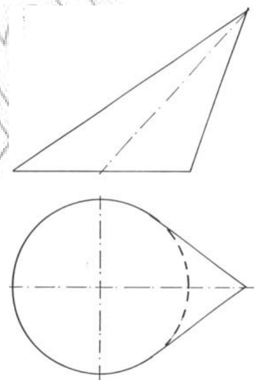

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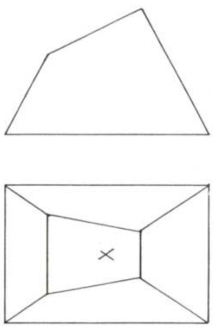

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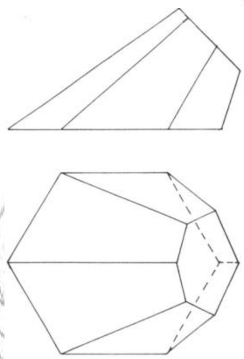

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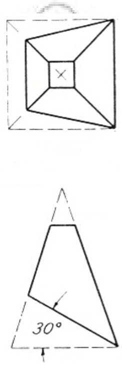

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