UNIT 6 SURFACE DEVELOPMENT

Structure

6.1 INTRODUCTION

The knowledge of development of surfaces is very useful in the sheet metal industry, where products like utensils, cans, buckets, hoppers, domes, etc. are manufactured. Imagine an industry where domestic refrigerators are manufactured. The ultimate shape of a refrigerator is made from the sheet metal. Its door is first made on a plain sheet and then cut and folded to form the door. To make a funnel out of a sheet, what should be the shape of the sheet which, when folded, forms the final shape of the funnel? A tailor first prepares a development drawing on a cloth to cut and stitch the correct shape and size of a shirt.

A development gives the shape and plane area of the material which enables the cost to be estimated. Development should be such as to allow the minimum waste of material when the shape is cut out.

Objectives

After studying this unit, you should be able to understand

- importance of studying the development of surfaces,
- development methods for commonly used objects such as cube, prism, pyramid, cone, cylinder and sphere,
- in sheet metal work, how to cut proper size of the sheet with development and then to fold at proper places to form the desired object, and

- sheet metal requirement and cost estimation for various types of objects to be fabricated.

6.2 GEOMETRIC OBJECTS

A layout of the complete surface of an object is called a development. Geometric solids are bounded by geometric surfaces. They may be classified as follows :

(a) Solids bounded by plane surfaces such as tetrahedron, cube, prism, and pyramid.

(b) Solids bounded by single curved surfaces such as cone and cylinder (generated by a moving straight line).

(c) Solids bounded by double curved surfaces such as sphere (surface of revolution generated by curved line).

6.3 DEVELOPMENT OF A SURFACE

If a solid is wrapped by thin paper in such a way that the paper does not have wrinkles and also it is not overlapping anywhere, then remove the paper and spread it on a plain surface. The shape of the paper is called the lateral development of that solid or pattern. If the development of the top and the bottom of the solid is also included, then it is called the total development of the surface.

Figure 6.1

Due to the fact that there is no distorting of the surface in the process of development, every line on the development must necessarily show the true length of the corresponding line on the surface. It is a coordinal principle which must always be kept in mind in constructing all the true developments.

6.4 DEVELOPMENT OF A CUBE

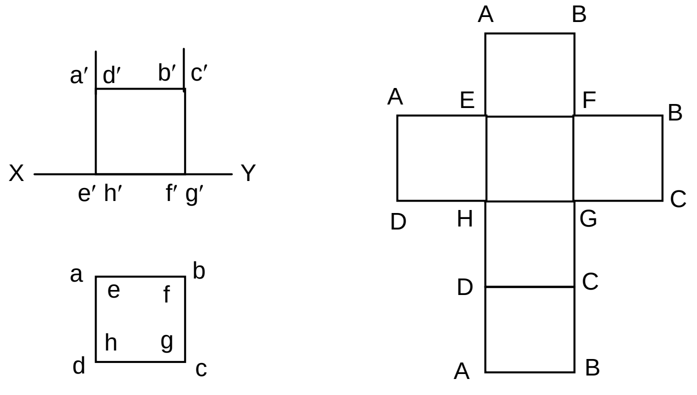
The cube is a regular polyhedra consisting of six equal faces, each a square.

Procedure

(a) Draw the elevation and plan of a cube resting on its base in HP with two of its vertical faces parallel to VP as shown in Figure 6.2(a).

(b) Mark the top and the bottom face as *a*, *b*, *c*, *d* and *e*, *f*, *g*, *h*, respectively, in plan and elevation.

(c) Note carefully the corners of the cube which are lettered. Develop the surface along the edges *EF*, *FG*, *GH*, *EH* and *DC* to get the complete development of the cube as in Figure 6.2(b).



(a) (b)

Figure 6.2

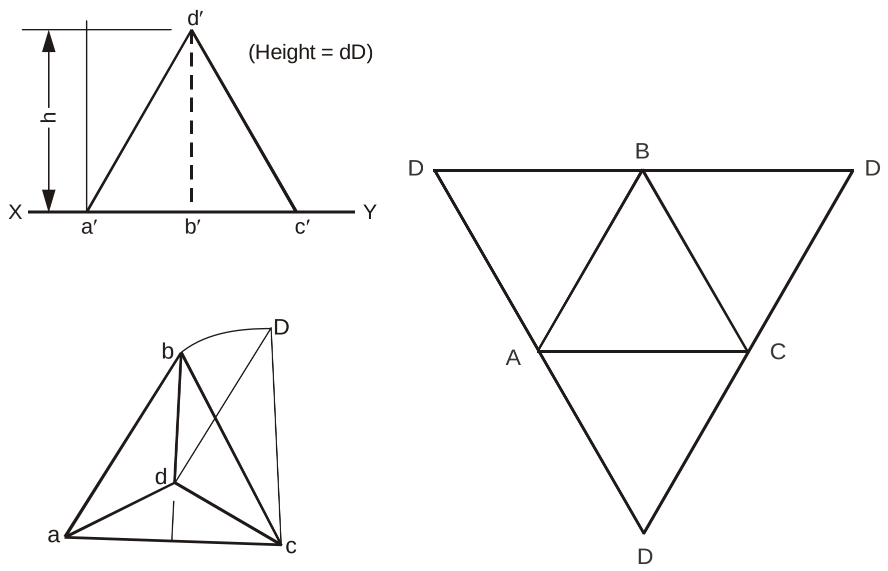
6.5 DEVELOPMENT OF A TETRAHEDRON

The tetrahedron is a regular polyhedra consisting of four equal faces, each an equilateral triangle.

Procedure

(a) Draw two views of the solid (Figure 6.3(a)).

(b) Mark the base as *a*, *b*, *c* and the apex as *d* in plan and elevation.



(a) (b)

Figure 6.3

(c) Develop the surface along the edges *AB*, *BC* and *AC* to get the development of the tetrahedron which has four equal equilateral triangles *ABC*, *ABD*, *BCD* and *ACD* (Figure 6.3(b)).

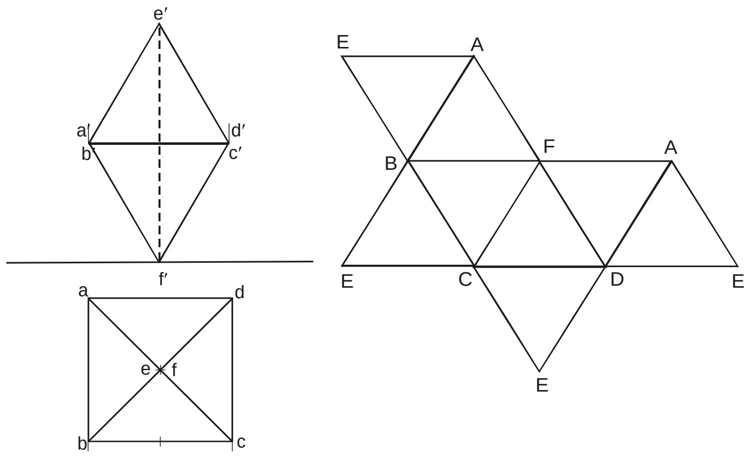
6.6 DEVELOPMENT OF A OCTAHEDRON

The octahedron is a regular polyhedra consisting of eight equal faces, each an equilateral triangle.

Procedure

(a) Draw the projection of the solid with an axis vertical and a face perpendicular to VP.

(b) Mark the corners *a*, *b*, *c*, *d*, *e* and *f* in plan and elevation, with *f* in HP (Figure 6.4(a)).



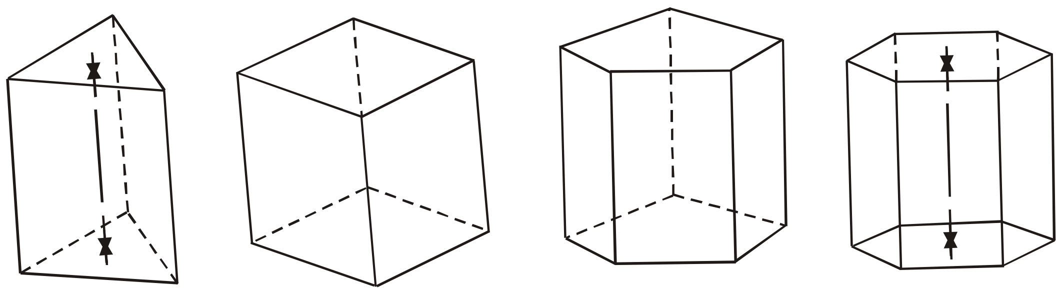
(a) **(b)**

Figure 6.4

(c) Locate *F* and draw equilateral triangles *FAB*, *FBC*, *FCD* and *FDA*. Now draw equilateral triangle *ABE* on *AB*, *BCE* on *BC*, *CDE* on *CD* and *DAE* on *DA* to complete the development.

6.7 DEVELOPMENT OF A PRISM

A prism is a geometric solid bounded by rectangular and vertical surfaces. A right and regular prism has its axis perpendicular to the base and the polygon at the base is called regular polygon. A right regular triangular, square, pentagonal and hexagonal prism is shown in Figures 6.5(a), (b), (c) and (d) respectively.



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

Figure 6.5

6.7.1 Development of the Surface of a Pentagonal Prism

Procedure

(a) Draw the front and top views of the prism (let it be a right and regular pentagonal prism).

(b) Draw the stretch-out lines A, A, and A_1, A_1 of lengths equal to the periphery of the base of the prism, which is equal to five times the side of the pentagon.

(c) Divide AA into five equal parts and draw vertical lines representing the edges.

AA, A_1 A_1 represent the lateral development of the pentagonal prism.

Figure 6.6

6.7.2 Development of the Surface of a Truncated Pentagonal Prism

Procedure

(a) Draw the front and top views of the prism.

(b) Locate the cutting plane, as given in the problem.

(c) Locate the points of intersection of the vertical edges and the cutting plane line.

Figure 6.7

(d) Draw stretch-out lines A, A and A_1, A_1 equal to the periphery of the base, which is equal to five times the side of the base.

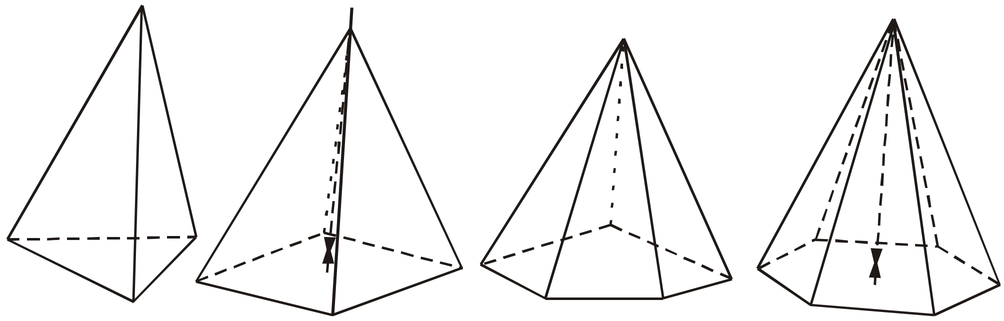
(e) Divide the line A, A in five equal parts and draw vertical edges through these divisions.

(f) From the point front view, draw horizontal lines from the intersection points and locate the points of intersection of these horizontal lines and vertical corresponding edges in the development.

(g) Join all these intersection points in the development by straight lines. The lower portion represents the lateral development of the portion *A* of the prism while the upper portion represents the lateral development of the portion *B* of the prism.

6.8 DEVELOPMENT OF A PYRAMID

A pyramid is a geometric solid with slant surfaces as isosceles triangles meeting at a point called apex and a base called polygon. A right and regular pyramid is that whose axis is perpendicular to the base and the base is a regular polygon. A right regular triangular, square, pentagonal and hexagonal pyramid is shown in Figures 6. 8(a), (b), (c) and (d) respectively.



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

Figure 6.8

6.8.1 Development of the Surface of a Square Pyramid

Procedure

(a) Draw the front and top view of the square pyramid.

(b) For determining the true length of the slant edge 2.0, rotate the line 0-2^o about 0 till it becomes parallel to HP. Say, the new position is

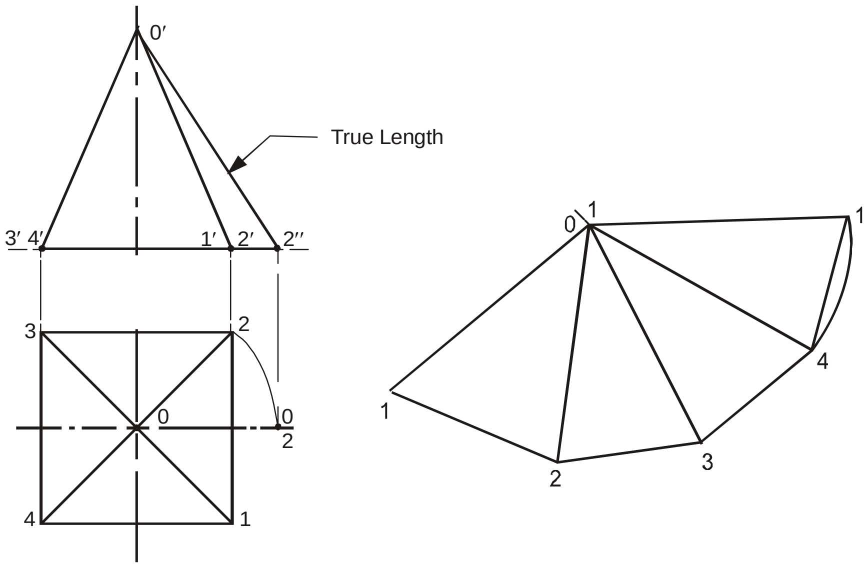


Figure 6.9

0-2°. Project 2° in the elevation and on the locus (horizontal line) of 2″. The new point of intersection is 2″ with 0″. The length 0″-2″ is the true length of the slant edge 0.2.

(c) Take radius equal to the true length of the slant edge, i.e. 0′-2″, and with any centre 0_1 draw an arc of a circle. Select any point 1 on the arc and join it with 0_1. With 1 as the centre and the radius equal to the base side of the pyramid (i.e. 50 mm), cut four divisions on the arc of the circle and mark them 1, 2, 3, 4 etc. Join 1, 2, 3 and 4 with 0_1. Join 1 with 2, 2 with 3, 3 with 4 and 4 with 1 by straight lines.

(d) These four isosceles triangles represent the lateral development of the pyramid.

6.8.2 Development of the Surface of a Truncated Pyramid

Procedure

(a) Draw the plan and elevation of the prism of Height *H* and side of base length *L* (Right regular square pyramid), base 1, 2, 3, 4 and apex as 0.

(b) It is cut by a horizontal cutting plane cutting the slant edges at *a*, *b*, *c*, *d* in plan and at *a′*, *b′*, *c′*, *d′* in elevation.

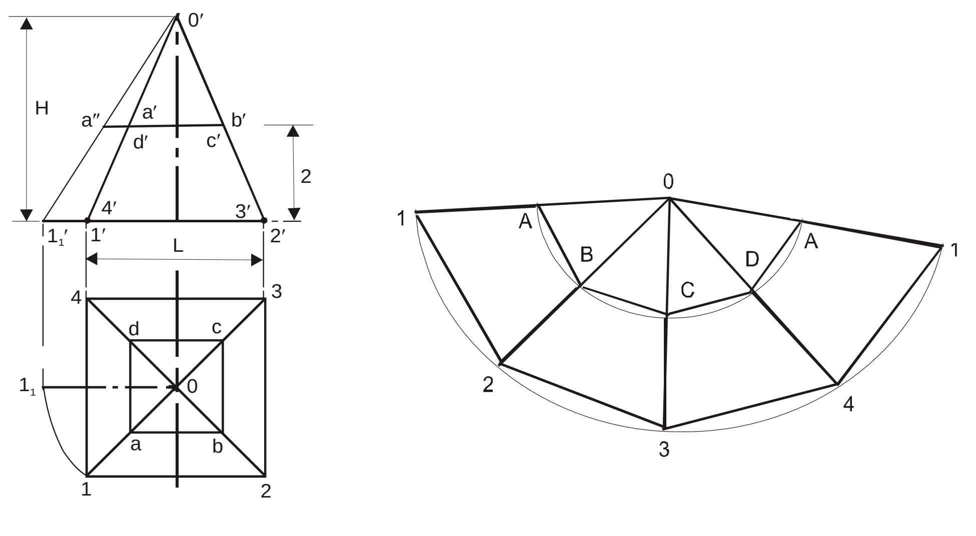


Figure 6.10

(c) None of the line 01, 02, 03 or 04 show the true length of the slant edge. Therefore, draw any one line say 01 horizontal (Parallel to *XY*) and determine the true length 0′ $1'_1$. Through a′ draw a horizontal line and obtain the true length $o'\ a''_1$.

(d) With *o* as center and radius $o'1_1'$ (true slant height) draw arc and mark 1, 2, 3, 4 and obtain the development of lateral surface of the pyramid.

(e) With *o* as center and radius $o'\ a''$ draw an arc cutting 01, 02, 03, and 04 at *A*, *B*, *C*, and *D* respectively. Draw line *AB*, *BC*, *CD* and *DA* and complete the development.

6.9 DEVELOPMENT OF THE SURFACE OF A RIGHT CYLINDER

Procedure

(a) Draw a plan and elevation of a cylinder with the given dimensions.

(b) Divide a circle (of the plan) in a number of equal parts (say 8) by drawing diameters. Project these divisions in the elevation. Each line in the elevation represents a generator.

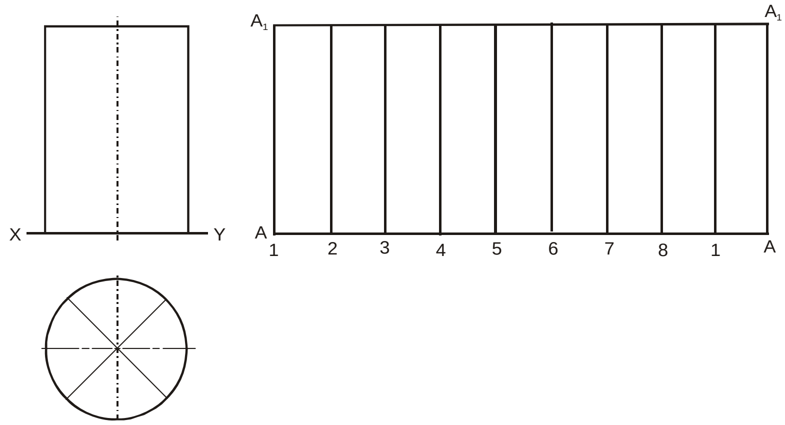


Figure 6.11

(c) Draw horizontal lines on the side of the elevation. These lines are called stretch-out lines (A A and A_1, A_1). The length of these lines is equal to the circumference of the cylinder $p \times D$, where D is the diameter of the cylinder.

(d) Divide the stretch-out line into the same number of equal parts in which the plan circle has been divided (here, eight parts).

(e) The rectangle (A A A_1 A_1), so obtained, is the development of the lateral surface of the cylinder.

6.9.1 Development of the Surface of a Truncated Cylinder

Procedure

(a) Draw the front and top views of a truncated cylinder.

(b) Divide the base circle into a number of equal parts and project the generator on the front view.

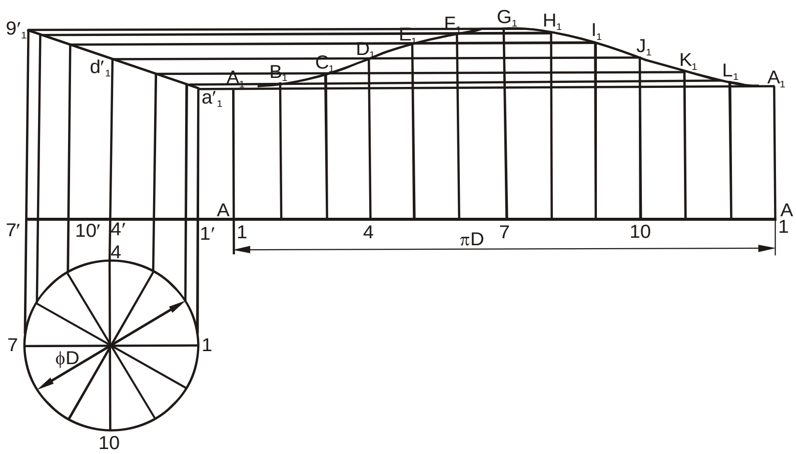


Figure 6.12

(c) Mark the points of intersection a_1, b_1, c_1, etc, between the generators and the truncated zone of the cylinder.

(d) Draw the stretch-out line equal to the circumference of the base of the cylinder.

(e) Divide the stretch-out line into the same number of equal parts as that of the base and draw the generators through them.

(f) Locate the points A_1, B_1, and C_1, etc. by a smooth curve.

[**Note :** The generators should not be drawn thick, since they do not represent the edges on the surface.]

6.10 DEVELOPMENT OF A RIGHT CONE

The development of a right circular cone is a sector of a circle having a radius equal to the slant height of the cone and an arc length equal to the circumference of its base.

Figure 6.13

Procedure

(a) Take radius as slant height *S* of the cone and draw an arc.

(b) Mark an included angle at the center equal to $\frac{r}{s} \times 360^{o}$, where *r* is radius of the base and *S* is the slant height to complete development.

6.10.1 Development of a Truncated Cone

Procedure

(a) Draw the two views of the given cone.

(b) Divide the base of the cone into equal number of parts (say 12) and locate the corresponding generators in plan and elevation.

(c) Locate the intersection points a' b' c' etc. in the elevation at which the generators are cut.

(d) Represent the lateral surface of the complete cone by a sector of a circle whose radius is equal to the slant height and mark off circumference by taking $1/12^{th}$ of base circle as arc to complete the development.

(e) Transfer the points *ABC* etc. onto the development by finding their true distance from the apex of the cone (To determine the true length of $o'c'$ draw horizontal through c' to intersect o' $1'$ at p' and on the generator 03 mark the distance *oc* equal to $o'p'$).

Figure 6.14

6.11 DEVELOPMENT OF A SPHERE

The surface of a sphere can be approximately developed by

(a) Zone method, and

(b) Lune mthod.

Zone Method

Figure 6.15 shows the top half of a sphere divided into four zones of equal width. By joining points *P*, *Q*, *R* and *S* by straight lines, each zone becomes a cone frustum, except the uppermost zone which becomes a cone of small altitude.

Figure 6.15

Development of these three cone frustums and the upper cone will give the development of a half sphere. For example, take the zone *C*. It is a frustum of cone whose vertex is at C_1. The surface of this frustum is shown developed in the front view. The length of the divisions on the arc is obtained from the top view. All the zones can be developed in the same manner.

Lune Method

A sphere may be divided into 12 lunes, one of which is shown in the front view. The semi-circle *qr* is the top view of the centre line of that lune. The length of the line is equal to the length of the arc *qr* and its maximum width is equal to *gh*.

Figure 6.16

Divide the semi-circle into a number of equal parts, say eight and project the division points on the front view to the points 1, 2, etc. With *q* as the centre and the radii equal to q' $1'$, q' $2'$ and *q* 3, draw arcs *ab*, *cd*, and *ef* which will show the widths of the lune at points 1 and 7, 2 and 6, 3 and 5 respectively.

Draw a line *QR* equal to the length of the arc *qr* (by stepping off eight divisions, each equal to the chord-length *q*1).

Draw a perpendicular at each division-points and make *AB* and *MN* equal to *ab* at points 1 and 7, *CD* and *KL* equal to *cd* at point 2 and 6. Draw smooth curves through point *Q*, *A*, *C*, etc. The figure thus obtained will be the approximate development of one-twelfth of the surface of the sphere.

SAQ 1

(a) Draw the development of the lateral surface of the pentagonal pyramid, 20 mm edge of base, 40 mm in height and place on HP with one of the edge of base parallel to VP. The lower part of the pyramid is removed by a cutting plane perpendicular to VP, inclined at 30^o to HP and passing from one corner to the base.

(b) A frustum of a square pyramid has its base 50 mm, side top 25 mm side and height 75 mm. Draw the development of its lateral surface (axis is vertical and a side of base is parallel to the VP). Show the line joining the mid-point of a top edge of one face with the mid-point of the bottom edge of the opposite face by the shortest distance.

(c) Draw the development of the lateral surface of the square prism edge of base 20 mm, height 40 mm, base resting on ground and all the edges of base equally inclined with VP. A hole of 20 mm diameter is drilled in it in such a way that axis of hole is perpendicular to VP, 20 mm above HP and 10 mm away from the axis of the prism.

SAQ 2

(a) Draw the development of the lateral surface of the part *P* of the cone shown in Figure 6.20(a).

(b) A cone of 70 mm diameter of base and axis length 100 mm rests on the HP on its base. Draw the projections of the cone and show on it the shortest path traced by a point starting from a point on the circumference of the base of the cone moving around it and reaching the same point.

(c) Three cylindrical pipes of 5 cm diameter form a *Y* piece as shown in the front view in Figure 6.22(a). Draw the development of the surface of each pipe.

6.12 SUMMARY

In making the development of a geometric surface of various solids, the opening should be determined first. Every line used in making the development must represent the true length of that line on the actual surface.

Development of lateral surface are generally developed and shown as presented here. Development of common solids such as cube, prism, pyramid cylinder, cone and sphere are made possible with the application of basic, graphic and geometric principles in conjunction with mathematics. If a development problem is resolved in basic geometric elements, the solution will be simpler.

6.13 ANSWERS TO SAQs

SAQ 1

(a)

Figure 6.17

(b)

Figure 6.18

(c)

Figure 6.19

SAQ 2

(a)

Figure 6.20

(b)

Figure 6.21

(c)

Figure 6.22

FURTHER READING

Bhatt, N. D., *Engineering Drawing*, Charotar Publishing House, New Delhi.

Narayan, K. L. and Kannaiah, P., *Engineering Drawing*, Tata McGraw Hill, New Delhi.

Nagar, N. K. and Purohit, R. B., *Engineering Drawing – Textbook for Class XI*, National Council of Educational Research and Training (NCERT), New Delhi.

ENGINEERING DRAWING

Engineering Drawing is universally known as the language of engineers. A drawing is the graphic representation of the object or its components. To satisfy the requirements and need of human beings, several objects, products or services are conceptualised by engineers and designed with the application of scientific principles. The details of construction or production of such an object are expressed by engineers in the form of drawings such that these can be produced and hence, used by consumers. The drawing is, therefore, considered as one of the fundamental subjects for any discipline of engineering profession throughout the world.

The drawings or graphics is a very vast subject having different requirements for different engineering disciplines. This course has been developed primarily as a base course for diploma level studies, which is common requirement for any branch of engineering. It consists of six units detailing the primary knowledge base, projections and surface developments.

Different basic equipment and instruments used in drafting, drawing sheets and their layouts, letters used, their sizes and styles, dimensions employed and scales used etc. are described in Unit 1.

Unit 2 deals with the basic problems in geometric construction essential for preparation of technical drawings. It also describes the uses of drawing instruments and various methods of preparation of drawings.

Any engineering article or product consists of several components and parts which are designed separately and represented on drawing sheets in the form of technical drawings. These product elements are then aggregated or assembled to manufacture the particular product. For simplifying the process of assembling the elements, the concepts of reference planes, dihedral angles, and projections need to be introduced. These basic concepts of projections, particularly the orthographic projections, are given in Unit 3.

Unit 4 deals with the problems of orthographic projections of solids. Towards the end, the unit describes various details of sections of solid.

In addition to orthogonal projections of planes and solids, i.e. 2D and 3D objects, the concepts of pictorial projections is also necessary to visualise clearly and fully the shape of the objects by the shop floor workers. The classifications of pictorial drawings particularly the procedures of drawing isometric and oblique projections are discussed in Unit 5.

In sheet metal industry manufacturing articles that contains same space within such as utensils, cans, buckets, hoppers, domes, refrigerators, cars, ships, aircrafts etc., the ultimate shape is achieved by sheet metal. The techniques of surface development and commonly employed methods to represent them in technical drawings are discussed in Unit 6.

With the study of this course, you will be able to read and understand the details of technical drawings prepared by experts and will be able to draw them independently.

We wish you a grand success in all your educational endeavours.