RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

New Scheme Based On AICTE Flexible Curricula

B.Tech. First Year

Branch- Common to All Disciplines

BT105	Engineering Graphics	2L-0T-2P	3Credits

Course Objective:

All phases of manufacturing or construction require the conversion of new ideas and design concepts into the basic line language of graphics. Therefore, there are many areas (civil, mechanical, electrical, architectural and industrial) in which the skills of the CAD technicians play major roles in the design and development of new products or construction. Students prepare for actual work situations through practical training in a new state-of-the-art computer designed CAD laboratory using engineering software. This course is designed to address:

- to prepare you to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- to prepare you to communicate effectively
- to prepare you to use the techniques, skills, and modern engineering tools necessary for engineering practice

Course Contents:

Traditional Engineering Graphics: Principles of Engineering Graphics; Orthographic Projection; Descriptive Geometry; Drawing Principles; Isometric Projection; Surface Development; Perspective; Reading a Drawing; Sectional Views; Dimensioning & Tolerances; True Length, Angle; intersection, Shortest Distance.

Computer Graphics: Engineering Graphics Software; -Spatial Transformations; Orthographic Projections; Model Viewing; Co-ordinate Systems; Multi-view Projection; Exploded Assembly; Model Viewing; Animation; Spatial Manipulation; Surface Modelling; Solid Modelling; Introduction to Building Information Modelling (BIM)

(Except the basic essential concepts, most of the teaching part can happen concurrently in the laboratory)

Module 1: Introduction to Engineering Drawing covering, Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales;

Module 2: Orthographic Projections covering, Principles of Orthographic Projections- Conventions - Projections of Points and lines inclined to both planes; Projections of planes inclined Planes - Auxiliary Planes;

Module 3: Projections of Regular Solids covering, those inclined to both the Planes- Auxiliary Views; Draw simple annotation, dimensioning and scale. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

Module 4: Sections and Sectional Views of Right Angular Solids covering, Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only)

Module 5: Isometric Projections covering, Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids;

Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions;

Module 6: Overview of Computer Graphics covering, listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids]

Module 7: Customisation & CAD Drawing consisting of set up of the drawing page and the printer, including scale settings, Setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles;

Module 8: Annotations, layering & other functions covering applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation, Computer-aided design (CAD) software modeling of parts and assemblies. Parametric and non-parametric solid, surface, and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, multiview, auxiliary, and section views. Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques; dimensioning and scale multi views of dwelling;

Module 9: Demonstration of a simple team design project that illustrates Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; meshed topologies for engineering analysis and tool-path generation for component manufacture; geometric dimensioning and tolerancing; Use of solid-modeling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying colour coding according to building drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modelling (BIM).

Goals & Outcomes:

- Introduction to engineering design and its place in society
- Exposure to the visual aspects of engineering design
- Exposure to engineering graphics standards
- Exposure to solid modelling
- Exposure to computer-aided geometric design
- Exposure to creating working drawings
- Exposure to engineering communication

Text/Reference Books:

1. Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House
2. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education
3. Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication
4. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers
5. (Corresponding set of) CAD Software Theory and User Manuals

Engineering Graphics (BT 105)

Module – I

Scales: Introduction to Engineering Drawing covering, Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales

Projections of Points, Straight Lines and Planes: Various types of projection System, Projection of Points in different quadrants, projections of lines and planes for parallel, perpendicular & inclined to horizontal and vertical reference planes.

Types of Lines:

Just as in English textbook the correct words are used for making correct sentences; in Engineering Graphics, the details of various objects are drawn by different types of lines. Each line has a definite meaning and sense to convey.

IS 10714 (Pint 20): 2001 (General principles of presentation on technical drawings) and SP 46:2003 specify the following types of lines and their applications:

- **Visible Outlines, Visible Edges:** Type 01.2 (Continuous wide lines). The lines drawn to represent the visible outlines/ visible edges / surface boundary lines of objects should be outstanding in appearance.
- **Dimension Lines:** Type 01.1 (Continuous narrow Lines) Dimension Lines are drawn to mark dimension.
- **Extension Lines:** Type 01.1 (Continuous narrow Lines)
- There are extended slightly beyond the respective dimension lines.
- **Construction Lines:** Type 01.1 **(Continuous narrow Lines)** Construction Lines are drawn for constructing drawings and should not be erased after completion of the drawing.
- **Hatching / Section Lines:** Type 01.1 **(Continuous Narrow Lines)** Hatching Lines are drawn for the sectioned portion of an object. These are drawn inclined at an angle of 45° to the axis or to the main outline of the section.
- **Guide Lines:** Type 01.1 **(Continuous Narrow Lines)** Guide Lines are drawn for lettering and should not be erased after lettering.
- **Break Lines:** Type 01.1 **(Continuous Narrow Freehand Lines)** Wavy continuous narrow line drawn freehand is used to represent break of an object.
- **Break Lines**: Type 01.1 **(Continuous Narrow Lines with Zigzags)** Straight continuous ~arrow line with zigzags is used to represent break of an object.
- **Dashed Narrow Lines:** Type 02.1 **(Dashed Narrow Lines)** Hidden edges / Hidden outlines of objects are shown by dashed lines of short dashes of equal lengths of about 3 mm, spaced at equal distances of about 1 mm. the points of intersection of these lines with the outlines / another hidden line should be clearly shown.
- **Center Lines:** Type 04.1 **(Long-Dashed Dotted Narrow Lines)** Center Lines are drawn at the center of the drawings symmetrical about an axis or both the axes. These are extended by a short distance beyond the outline of the drawing.
- **Cutting Plane Lines:** Type 04.1 and Type 04.2 Cutting Plane Line is drawn to show the location of a cutting plane. It is long-dashed dotted narrow line, made wide at the ends, bends and change of direction. The direction of viewing is shown by means of arrows resting on the cutting plane line.
- **Border Lines** Border Lines are continuous wide lines of minimum thickness 0.7 mm

Use of Lines:

Types of Lines and their applications (IS 10714 (Part 20): 2001) and BIS: SP46: 2003

S. No.	Line description and Representation	Applications
1.1	Continuous narrow line B	Dimension lines, Extension lines
		Leader lines, Reference lines
		Short centre lines
		Projection lines
		Hatching
		Construction lines, Guide lines
		Outlines of revolved sections
		Imaginary lines of intersection
1.1	Continuous narrow freehand line C	Preferably manually represented termination of partial or interrupted views, cuts and sections, if the limit is not a line of symmetry or a center line·
1.1	Continuous narrow line with zigzags A	Preferably mechanically represented termination of partial or interrupted views. cuts and sections, if the limit is not a line of symmetry or a center line
1.2	Continuous wide line	Visible edges, visible outlines
		Main representations in diagrams, maps. flow charts
2.1	Dashed narrow line D - - - - - - - - - - - - - - - -	Hidden edges
		Hidden outlines
4.1	Long-dashed dotted narrow line E	Center lines / Axes. Lines of symmetry
		Cutting planes (Line 04.2 at ends and changes of direction)
4.2	Long-dashed dotted wide line F	Cutting planes at the ends and changes of direction outlines of visible parts situated m front of cutting plane

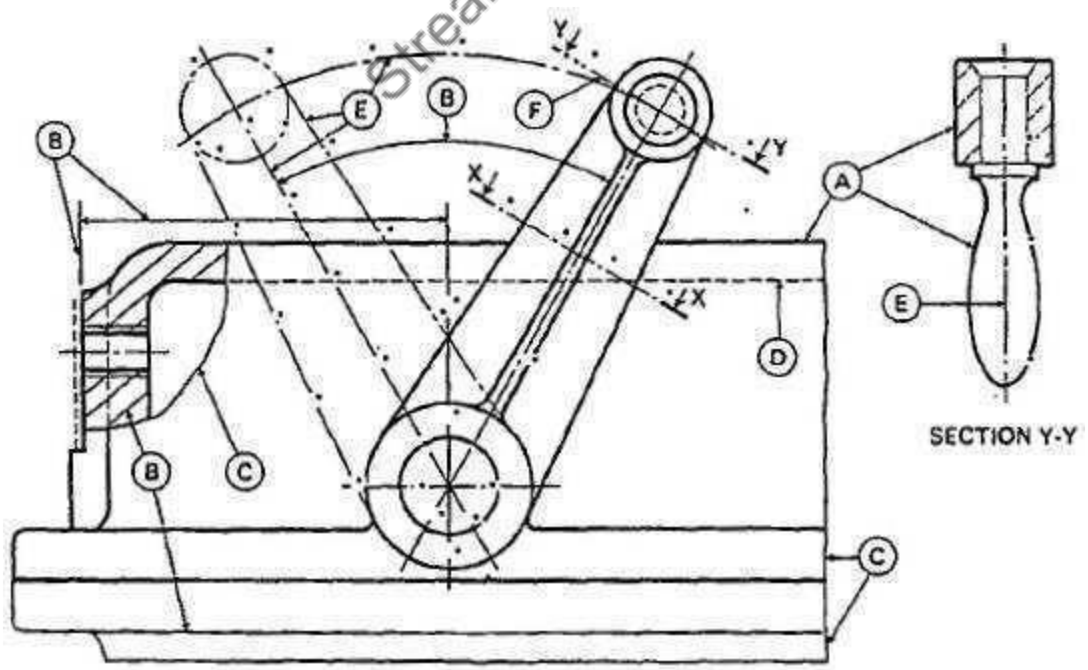


Fig. 1.1 Types of Lines

Lettering:

The essential features of lettering on technical drawings are legibility, uniformity and suitability for microfilming and other photographic reproductions. In order to meet these requirements, the characters are to be clearly distinguishable from each other in order to avoid any confusion between them, even in the case of slight mutilations. The reproductions require the distance between two adjacent lines or the space between letters to be at least equal to twice the line thickness. The line thickness for lower case and capital letters shall be the same in order to facilitate lettering.

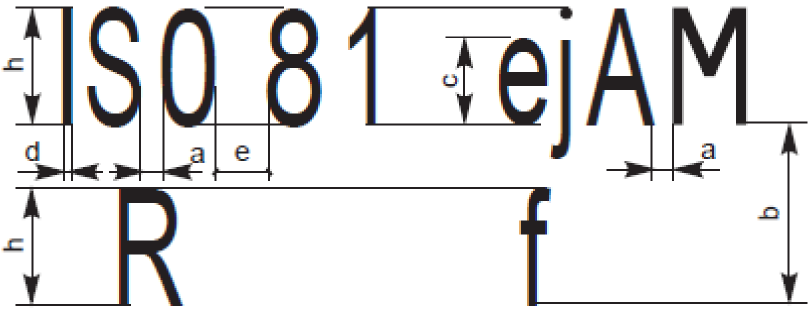


Fig. 1.2 Dimensions of lettering

Dimension of Lettering:

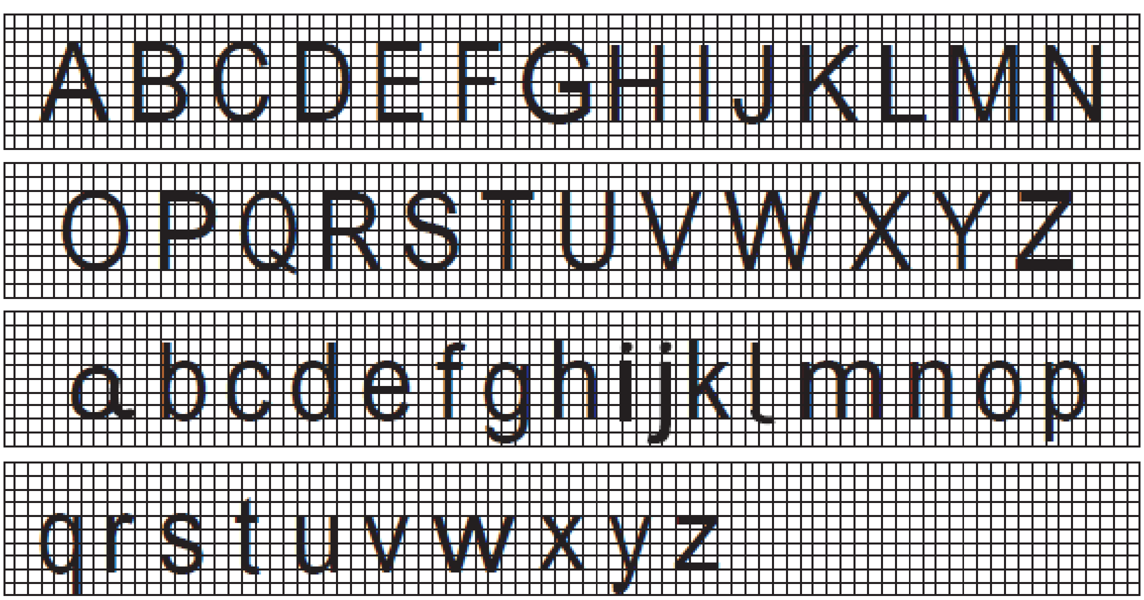
The following specifications are given for the dimensions of letters and numerals:

(i) The height of capital letters is taken as the base of dimensioning (Tables 2.6 and 2.7).

(ii) The two standard ratios for d/h, 1/14 and 1/10 are the most economical, as they result in a minimum number of line thicknesses.

(iii) The lettering may be inclined at 15° to the right, or may be vertical.

Characteristic		Dimensions, (mm)						
Lettering height (Height of capitals)	h (14/14)h	2.5	3.5	5	7	10	14	20
Height of lower-case letters (without stem or tail)	c (10/14)h	—	2.5	3.5	5	7	10	14
Spacing between characters	a (2/14)h	0.35	0.5	0.7	1	1.4	2	2.8
Minimum spacing of base lines	b (20/14)h	3.5	5	7	10	14	20	28
Minimum spacing between words	e (6/14)h	1.05	1.5	2.1	3	4.2	6	8.4
Thickness of lines	d (1/14)h	0.18	0.25	0.35	0.5	0.7	1	1.4



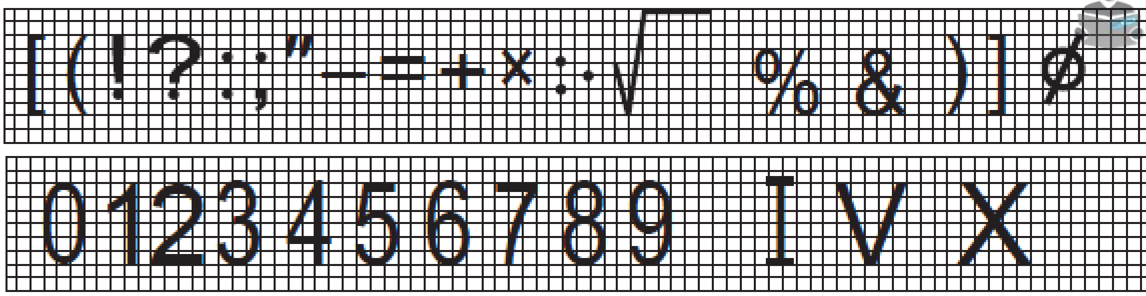


Fig. 1.3 Lettering

Dimensioning:
A drawing of a component, in addition to providing complete shape description, must also furnish information regarding the size description. These are provided through the distances between the surfaces, location of holes, nature of surface finish, type of material, etc. The expression of these features on a drawing, using lines, symbols, figures and notes is called dimensioning.

General Principles:
Dimension is a numerical value expressed in appropriate units of measurement and indicated on drawings, using lines, symbols, notes, etc., so that all features are completely defined.
1. As far as possible, dimensions should be placed outside the view.
2. Dimensions should be taken from visible outlines rather than from hidden lines.
3. Dimensioning to a centre line should be avoided except when the centre line passes through the centre of a hole.
4. Each feature should be dimensioned once only on a drawing.
5. Dimensions should be placed on the view or section that relates most clearly to the corresponding features.
6. Each drawing should use the same unit for all dimensions, but without showing the unit symbol.
7. No more dimensions than are necessary to define a part should be shown on a drawing.
8. No features of a part should be defined by more than one dimension in any one direction.

Method of Execution:
The elements of dimensioning include the projection line, dimension line, leader line, dimension line termination, the origin indication and the dimension itself. The various elements of dimensioning are shown in Fig. 1.4 a and b. The following are some of the principles to be adopted during execution of dimensioning:

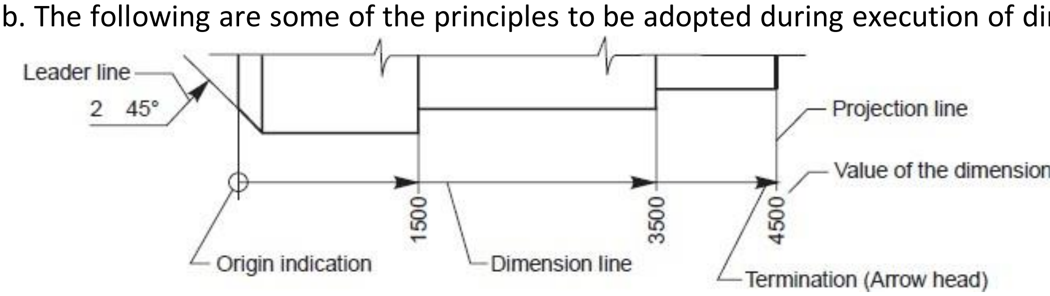


Fig. 1.4 (a) Elements of Dimensioning

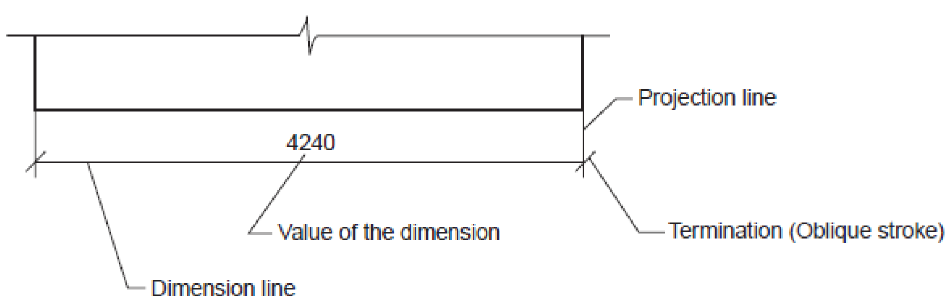
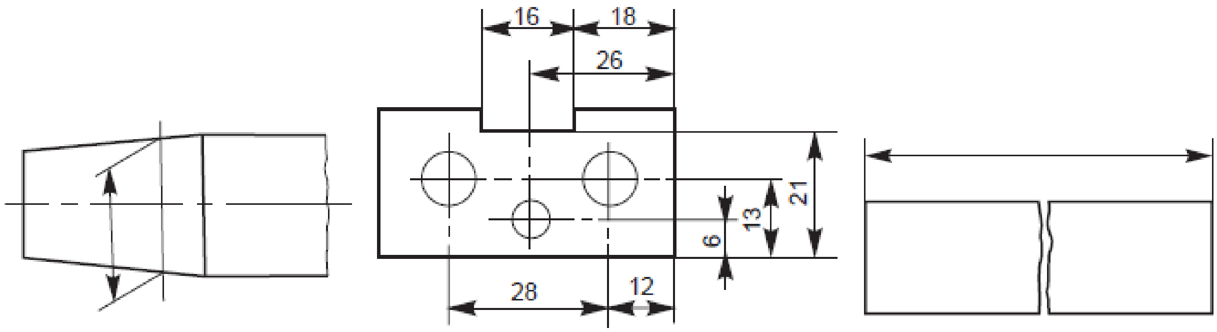


Fig. 1.4 (b) Elements of Dimensioning

1. Projection and dimension lines should be drawn as thin continuous lines.
2. Projection lines should extend slightly beyond the respective dimension lines.
3. Projection lines should be drawn perpendicular to the feature being dimensioned.
Where necessary, they may be drawn obliquely, but parallel to each other (Fig. 1.5 a). However, they must be in contact with the feature.
4. Projection lines and dimension lines should not cross each other, unless it is unavoidable (Fig. 1.5 b).
5. A dimension line should be shown unbroken, even where the feature to which it refers, is shown broken (Fig. 1.5 c).
6. A centre line or the outline of a part should not be used as a dimension line, but may be used in place of projection line (Fig. 1.5 b).

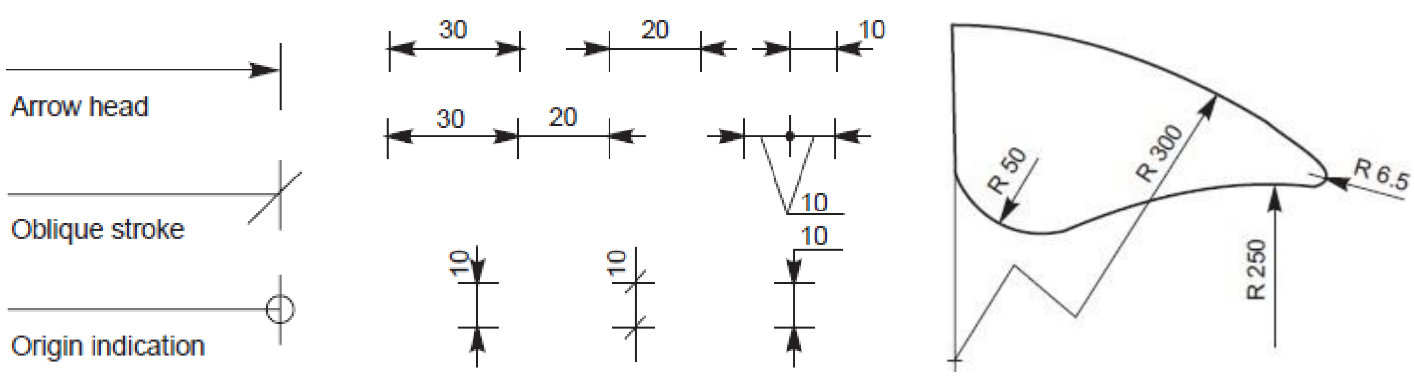


(a) (b) (b)

Fig. 1.5

Termination and Origin Indication

Dimension lines should show distinct termination, in the form of arrow heads or oblique strokes or where applicable, an origin indication. Two dimension line terminations and an origin indication are shown in Fig. 1.6 (a). In this,
1. the arrow head is drawn as short lines, having an included angle of 15°, which is closed and filled-in.
2. the oblique stroke is drawn as a short line, inclined at 45°.
3. the origin indication is drawn as a small open circle of approximately 3 mm in diameter.
The size of the terminations should be proportionate to the size of the drawing on which they are used. Where space is limited, arrow head termination may be shown outside the intended limits of the dimension line that is extended for that purpose. In certain other cases, an oblique stroke or a dot may be substituted (Fig. 1.6 (b)).
Where a radius is dimensioned, only one arrow head termination, with its point on the arc end of the dimension line, should be used (Fig. 1.6 (c)). However, the arrow head termination may be either on the inside or outside of the feature outline, depending upon the size of feature.



(a) (b) (c)

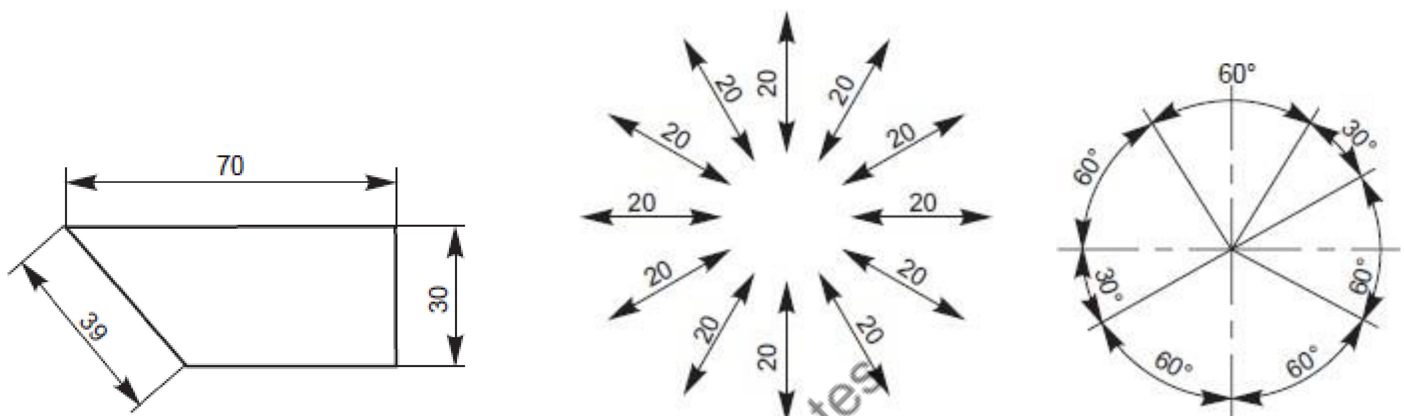
Fig. 1.6

Methods of Indicating Dimensions

Dimensions should be shown on drawings in characters of sufficient size, to ensure complete legibility. They should be placed in such a way that they are not crossed or separated by any other line on the drawing. Dimensions should be indicated on a drawing, according to one of the following two methods. However, only one method should be used on any one drawing.

METHOD–1 (Aligned System)

Dimensions should be placed parallel to their dimension lines and preferably near the middle, above and clear-off the dimension line (Fig. 1.7 a). Dimensions may be written so that they can be read from the bottom or from the right side of the drawing. Dimensions on oblique dimension lines should be oriented as shown in Fig. 1.7 b. Angular dimensions may be oriented as shown in Fig. 1.7 c.

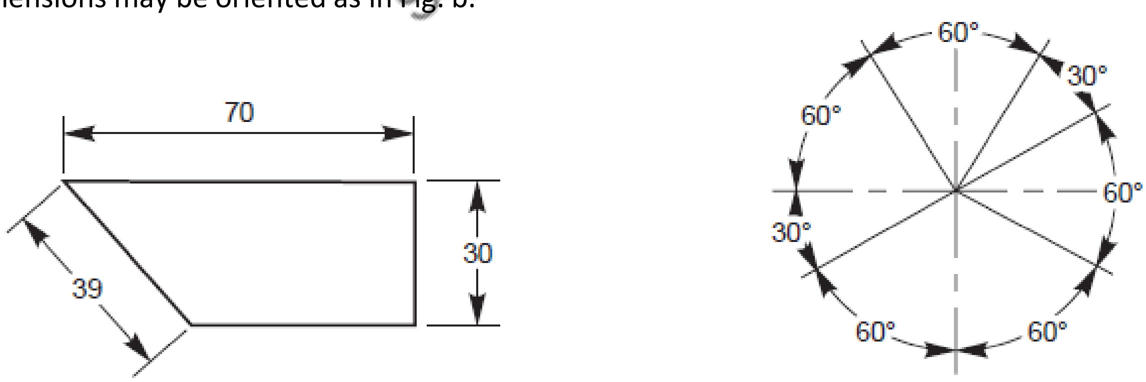


(a) (b) Oblique dimensioning (c)Angular dimensioning

Fig. 1.7

METHOD–2 (Unidirectional System)

Dimensions should be indicated so that they can be read from the bottom of the drawing only. Non-horizontal dimension lines are interrupted, preferably near the middle, for insertion of the dimension (Fig. a).
Angular dimensions may be oriented as in Fig. b.



(a) (b) Angular dimensioning

Fig. 1.8

Arrangement of Dimensioning

The arrangement of dimensions on a drawing must indicate clearly the design purpose. The following are the ways of arranging the dimensions.

i) Chain Dimensions:

Chains of single dimensions should be used only where the possible accumulation of tolerances does not endanger the functional requirement of the part.

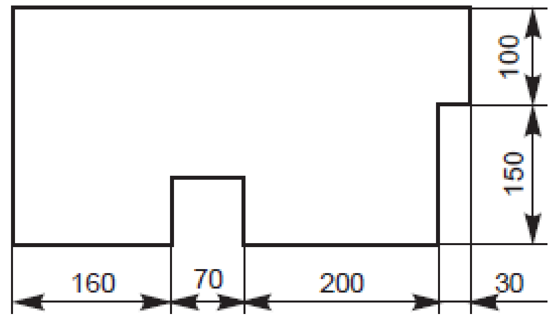


Fig. 1.9 Chain Dimensioning

ii) Parallel Dimensions:

In parallel dimensioning, a number of dimension lines, parallel to one another and spaced-out are used. This method is used where a number of dimensions have a common datum feature.

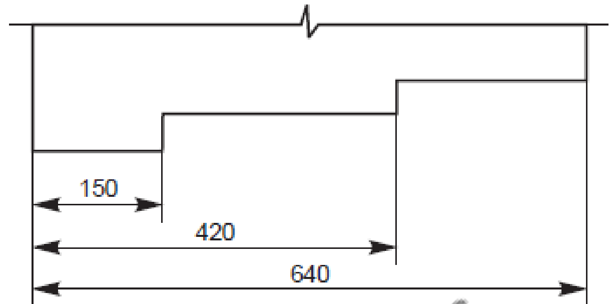


Fig. 1.10 Parallel Dimensioning

iii) Super imposed Running Dimensions:

These are simplified parallel dimensions and may be used where there are space limitations.

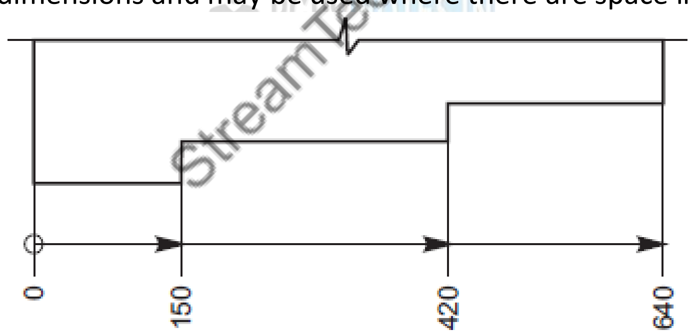


Fig. 1.11 Superimposed Running Dimensioning

iv) Combined Dimensions:

These are the result of simultaneous use of chain and parallel dimensions.

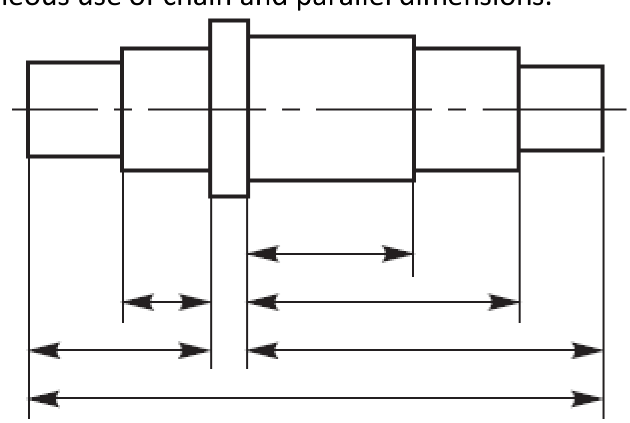
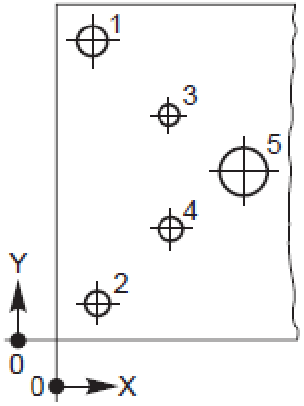


Fig. 1.12 Combined Dimensioning

v) Coordinate Dimensions:

The sizes of the holes and their co-ordinates may be indicated directly on the drawing; or they may be conveniently presented in a tabular form, as shown in Fig. 1.13.



	X	Y	ϕ
1	20	160	15.5
2	20	20	13.5
3	60	120	11
4	60	60	13.5
5	100	90	26
6			
7			
8			
9			
10			

Fig. 1.13 Coordinate Dimensioning

Scales:

It is not possible always to make drawings of an object to its actual size. If the actual linear dimensions of an object are shown in its drawing, the scale used is said to be a full size scale. Wherever possible, it is desirable to make drawings to full size.

Reducing and Enlarging Scales

Objects which are very big in size cannot be represented in drawing to full size. In such cases the object is represented in reduced size by making use of reducing scales. Reducing scales are used to represent objects such as large machine parts, buildings, town plans etc. A reducing scale, say 1: 10 means that 10 units length on the object is represented by 1 unit length on the drawing.

Similarly, for drawing small objects such as watch parts, instrument components etc., use of full scale may not be useful to represent the object clearly. In those cases enlarging scales are used.

An enlarging scale, say 10: 1 means one unit length on the object is represented by 10 units on the drawing.

The designation of a scale consists of the word SCALE, followed by the indication of its ratio as follows.

Scale 1: 1 for full size scale

Scale 1: x for reducing scales (x = 10, 20 .... etc.)

Scale x: 1 for enlarging scales.

Note: For all drawings the scale has to be mentioned without fail.

Representative fraction (R.F.):-

$$\text{RF} = \frac{\text{Drawing size of an object}}{\text{Its actual size}} \text{ (in same units)}$$

When a 1 cm long line in a drawing represents 1 meter length of the object

$$R.F. = \frac{1cm}{1m} = \frac{1}{100}$$

LENGTH OF SCALE = R.F. MAX. LENGTH TO BE MEASURED

Units of Measurement: -

Metric System	British System
1 Kilometer (km) = 10 Hectometer (hm)	1 League = 3 Miles (mi)
1 Hectometer (hm) = 10 Decameter (Dm)	1 Mile (mi) = 8 Furlongs (fur)
1 Decameter (Dm) = 10 Meter (m)	1 Furlong (fur) = 10 Chains (ch)
1 Meter (m) = 10 Decimeter (dm)	1 Chain (ch) = 22 Yards (yd)
1 Decimeter (dm) = 10 Centimeter (cm)	1 Yard (yd) = 3 Feet (ft)
1 Centimeter (cm) = 10 Millimeter (mm)	1 Foot (ft) = 12 Inches (in)
	1 Inch (in) = 8 Eighth

Linear Conversion: -
1 Mile (mi) = 1.609 Kilometer (km)
1 Inch (in) = 2.54 Centimeter (cm) = 25.4 Millimeter (mm)

Area Conversion: -
1 are (a) = 100 Square Meter (m^2)
1 Hectare (ha) = 100 ares = 10000 Square Meter (m^2)
1 Square Mile (mi^2) = 640 Acres (ac)
1 Acre (ac) =10 Square Chain (ch^2) = 4840 Square Yards (yd^2)

1. Plain Scales (for dimensions up to single decimal)
2. Diagonal Scales (for dimensions up to two decimals)
3. Vernier Scales (for dimensions up to two decimals)
4. Comparative Scales (for comparing two different units)
5. Scale of Cords (for measuring/constructing angles)

Plain Scale

Problem No. 1: - Construct a scale of 1:4, to show centimeters and long enough to measure up to 5 decimeters.

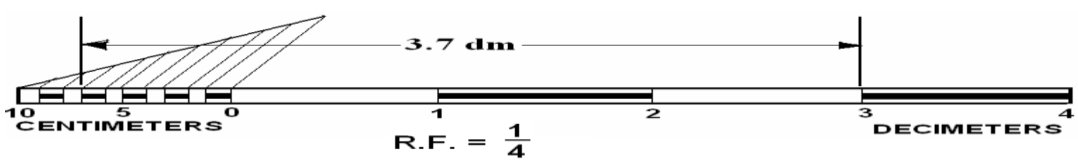


Fig. 1.14

CONSTRUCTION: -
1. R.F. = ¼
2. Length of the scale = R.F. x max. Length = ¼ ×5 dm = 12.5 cm.
3. Draw a line 12.5 cm long and divide it in to 5 equal divisions, each representing 1 dm.
4. Mark 0 at the end of the first division and 1, 2, 3 and 4 at the end of each subsequent division to its right.
5. Divide the first division into 10 equal sub-divisions, each representing 1 cm.
6. Mark cm to the left of 0 as shown.

Diagonal Scale

Problem No. 2: - Construct a Diagonal scale of RF = 3:200 (i.e. 1:66 2/3) showing meters, decimeters and centimeters. The scale should measure up to 6 meters. Show a distance of 4.56 meters

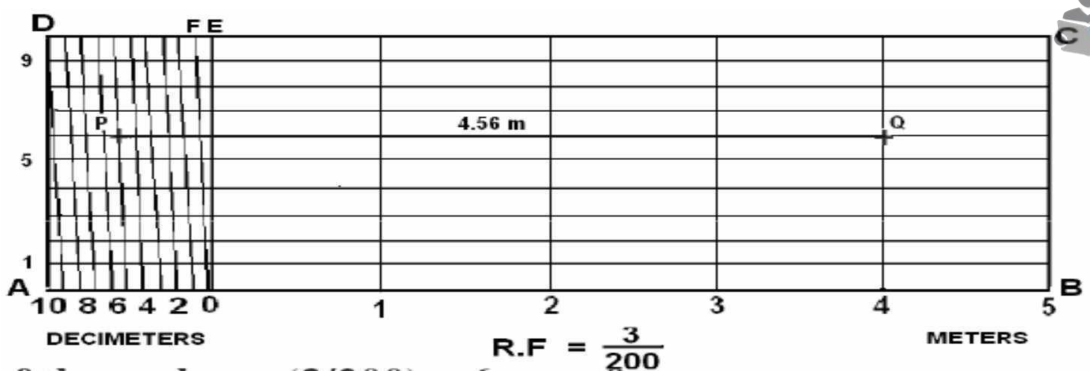


Fig. 1.15

CONSTRUCTION: -

1. Length of the scale = (3/200) x 6 m = 9 cm
2. Draw a line AB = 9 cm. Divide it in to 6 equal parts.
3. Divide the first part A0 into 10 equal divisions.
4. At A draw a perpendicular and step-off along it 10 equal divisions, ending at D.
5. Complete the rectangle ABCD.
6. Draw perpendiculars at meter-divisions i.e. 1, 2, 3, and 4.
7. Draw horizontal lines through the division points on AD. Join D with the end of the first division along A0 (i.e. 9).
8. Through the remaining points i.e. 8, 7, 6…draw lines // to D9.
9. PQ = 4.56 meters

<u>**Vernier Scale**</u>

The vernier scale is a short auxiliary scale constructed along the plain or main scale, which can read up to two decimal places.

The smallest division on the main scale and vernier scale are 1 msd or 1 vsd respectively. Generally (n+1) or (n-1) divisions on the main scale is divided into n equal parts on the Vernier scale.

Thus, 1 vsd (Vernier Scale Division) = $(n-1)/n$ msd (Main Scale Division)

When 1 vsd < 1 it is called forward or direct vernier. The vernier divisions are numbered in the same direction as those on the main scale.

When 1 vsd > 1 or (1 + l/n), It is called backward or retrograde vernier. The vernier divisions are numbered in the opposite direction compared to those on the main scale.

The least count (LC) is the smallest dimension correct to which a measurement can be made with a vernier.

For forward vernier, L C = (1 msd - 1 vsd)

For backward vernier, LC = (1 vsd - 1 msd)

Problem No. 3: - Draw a Vernier scale of R.F. = 1/25 to read up to 4 meters. On it show lengths 2.39 m and 0.91 m.

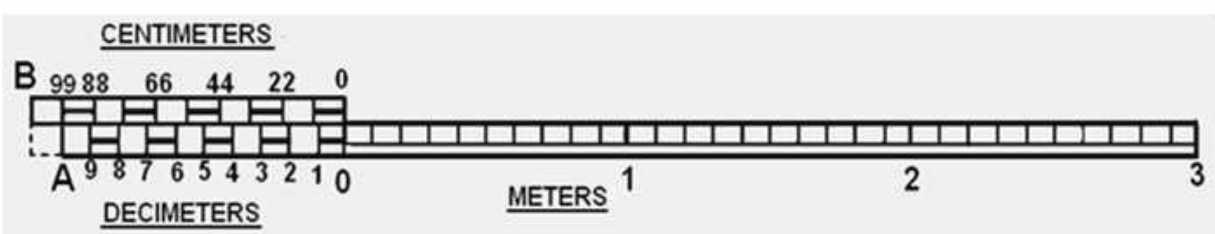


Fig. 1.16

CONSTRUCTION: -

1. Length of Scale = (1/25) × (4 × 100) = 16 cm
2. Draw a 16 cm long line and divide it into 4 equal parts. Each part is 1 meter. Divide each of these parts in to 10 equal parts to show decimeter (10 cm).
3. Take 11 parts of dm length and divide it in to 10 equal parts. Each of these parts will show a length of 1.1 dm or 11 cm.
4. To measure 2.39 m, place one leg of the divider at *A* on 99 cm mark and other leg at *B* on 1.4 mark. (0.99 + 1.4 = 2.39).
5. To measure 0.91 m, place the divider at *C* and *D* (0.8 +0.11 = 0.91).

Scale of Chord

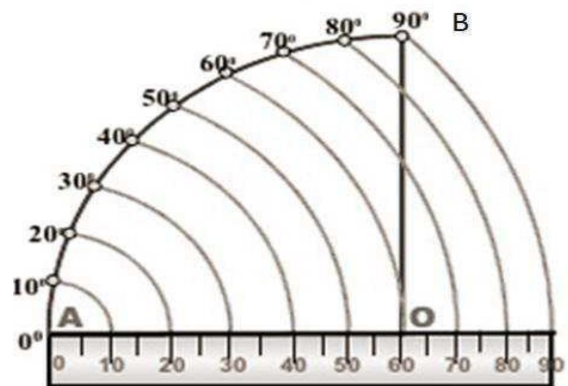


Fig. 1.17

CONSTRUCTION: -

1. Draw sector of a circle 90ºwith "OA" radius. ('OA' ANY CONVINIENT DISTANCE)
2. Divide this angle in nine equal parts of 10º each.
3. Name as shown from end 'A' upwards.
4. From 'A' as centre with cords of each angle as radius. Draw arcs downwards up to 'AO' Line OR its extension and from a scale with proper labeling as shown. As cord lengths are to measure & construct different angles it is called scale of cords.

Conic Sections:

Cone is formed when a right angled triangle with an apex and angle e is rotated about its altitude as the axis. The length or height of the cone is equal to the altitude of the triangle and the radius of the base of the cone is equal to the base of the triangle. The apex angle of the cone is 2 e.

When a cone is cut by a plane, the curve formed along the section is known as a conic. For this purpose, the cone may be cut by different section planes and the conic sections obtained are shown in Fig.

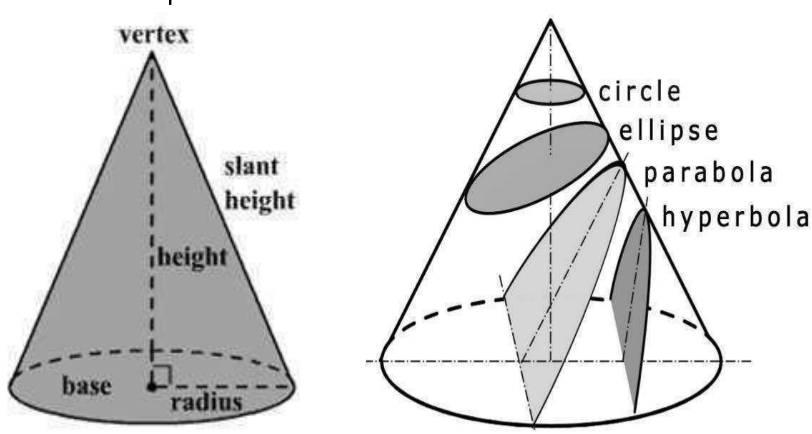


Fig. 1.18

1. Circle

When a cone is cut by a section plane making an angle α = 90° with the axis, the section obtained is a circle.

2. Ellipse

When a cone is cut by a section plane at an angle, α more than half of the apex angle i.e., e and less than 90°, the curve of the section is an ellipse. Its size depends on the angle α and the distance of the section plane from the apex of the cone.

3. Parabola

If the angle α is equal to e i.e., when the section plane is parallel to the slant side of the cone, the curve at the section is a parabola. This is not a closed figure like circle or ellipse. The size of the parabola depends upon the distance of the section plane from the slant side of the cone.

4. Hyperbola

If the angle α is less than e, the curve at the section is hyperbola. The curve of intersection is hyperbola, even if α = e, provided the section plane is not passing through the apex of the cone. However if the section plane passes through the apex, the section produced is an isosceles triangle.

Ellipse

Conic Sections as Loci of a Moving Point

A conic section may be defined as the locus of a point moving in a plane such that the ratio of its distance from a fixed point (Focus) and fixed straight line (Directrix) is always a constant. The ratio is called eccentricity. The line passing through the focus and perpendicular to the directrix is the axis of the curve. The point at which the conic section intersects the axis is called the vertex or apex of the curve.

e<1 for Ellipse, e=1 for Parabola & e>1 for Hyperbola.

Various Methods for Construction of an Ellipse

a) General method,
b) Arc of circle Method,
c) Concentric Circle Method
d) Oblong Method

a) General method:

Problem: To draw an Ellipse with eccentricity equal to 2/3 for the above problem.

Solution: Construction is similar to the one in Figure to draw an ellipse including the tangent and normal. Following are the details of drawing different conic sections with the help of general or eccentricity method.

1. Draw the axis AB and the directrix CD at right angles to it:
2. Mark the focus F on the axis at 50mm.
3. Locate the vertex V on AB such that AV = VF
4. Draw a line VE perpendicular to AB such that VE = VF\
5. Join A, E and extend. Now, VENA = VFNA = 1, the eccentricity.
6. Locate number of points 1, 2, 3, etc., to the right of V on the axis, which need not be equidistant.
7. Through the points 1,2,3, etc., draw lines perpendicular to the axis and to meet the line AE extended at 1',2',3' etc.
8. With centre F and radius 1-1'draw arcs intersecting the line through I at P I and P'1'.
9. Similarly, locate the points P_2 etc., on either side of the axis. Join the points by smooth curve, forming the required ellipse.

To draw a normal and tangent through a point 40 mm from the directrix.

To draw a tangent and normal to the parabola, locate the point M which is at 40 mm from the direct QX. Then join M to F and draw a line through F, perpendicular to MF to meet the directrix at T. The line joining T and M and extended is the tangent and a line NN, through M and perpendicular to TM is the normal to the curve.

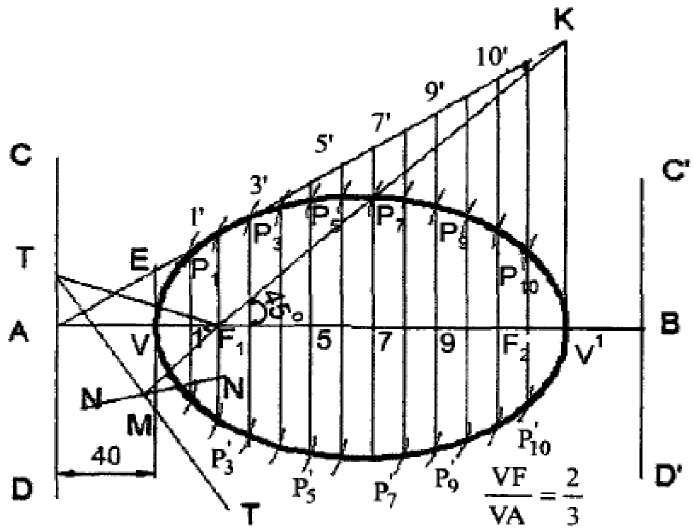


Fig. 1.19 Ellipse by General Method

b) Arc of circle Method

Problem: To draw an ellipse with major and minor axes equal to 120 mm and 80 mm respectively.

Solution:

1. Draw the major (AB) and minor (CD) axes and locate the centre O.
2. Locate the foci F_1 and F_2 by taking a radius equal to 60 mm (112 of AB) and cutting AB at F_1P_1 and F_2 with C as the centre.
3. Mark a number of points 1, 2, 3 etc., between F_1 and O, which need not be equidistance.
4. With centers F_1 and F_2 and radii A_1 and B_1 respectively, draw arcs intersecting at the points PI and P;
5. Again with centers F_1 and F_2 and radii B_1 and A_1 respectively, draw arcs intersecting at the points Q_1 and Q_1'.
6. Repeat the steps 4 and 5 with the remaining points 2, 3, 4 etc., and obtain additional points on the curve. Join the points by a smooth curve, forming the required ellipse.
7. To mark a Tangent and Normal to the ellipse at any point, say M on it, join the foci F1 and F2 with M and extend FM to E and bisect the angle EMF_1. The bisector TT represents the required tangent and a line NN drawn through M and perpendicular to TT is the normal to the ellipse.

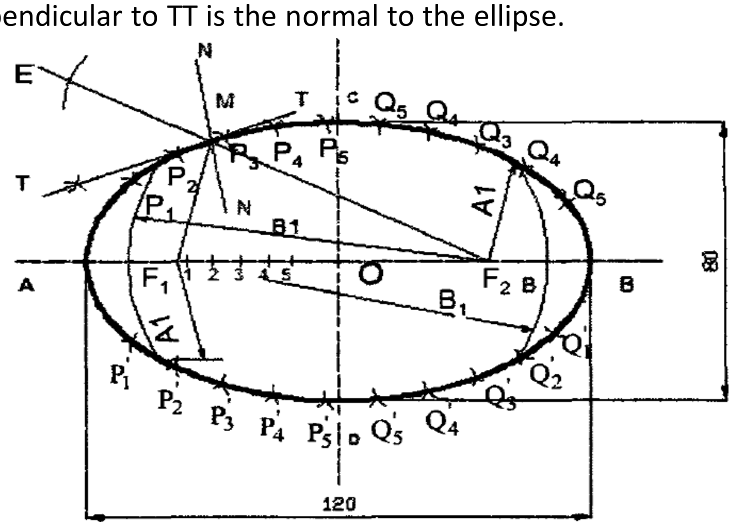


Fig. 1.20 Ellipse by Arcs of a Circle Method

c) Concentric Circle Method

Solution:

1. Draw the major and minor axes AB and CD and locate the centre O.
2. With centre 0 and major axis and minor axes as diameters, draw two concentric circles.
3. Divide both the circles into equal number of parts, say 12 and draw the radial lines.
4. Considering the radial line 0-1' -1, draw a horizontal line from I' to meet the vertical line from 1 at P_1'.
5. Repeat the steps 4 and obtain other points P_2, P_3, etc.
6. Join the points by a smooth curve forming the required ellipse.

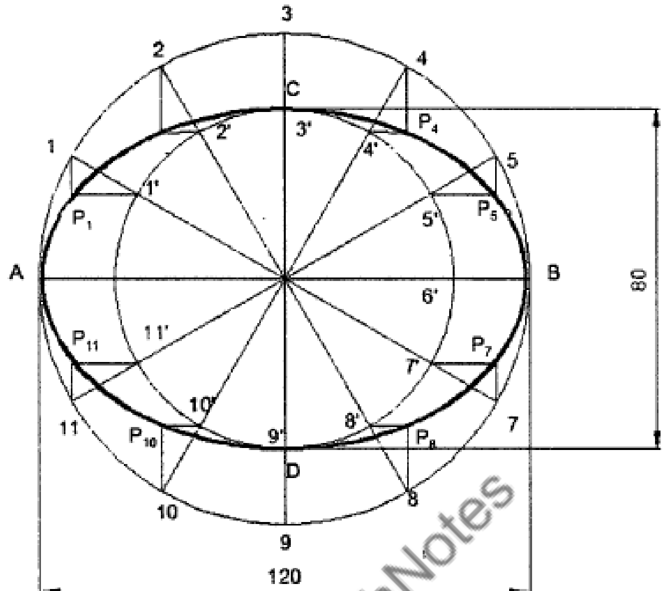


Fig. 1.21 Ellipse by Concentric Circle Method

d) Oblong Method

1. Draw the major and minor axes AB and CD and locate the centre O.
2. Draw the rectangle KLMN passing through A, D, B, C.
3. Divide AO and AN into same number of equal parts, say 4.
4. Join C with the points 1',2 ', 3' .
5. Join D with the points 1, 2, 3 and extend till they meet the lines C_1', C_2', C_3' respectively at P_1, P_2 and P_3.
6. Repeat steps 3 to 5 to obtain the points in the remaining three quadrants.
7. Join the points by a smooth curve forming the required ellipse.

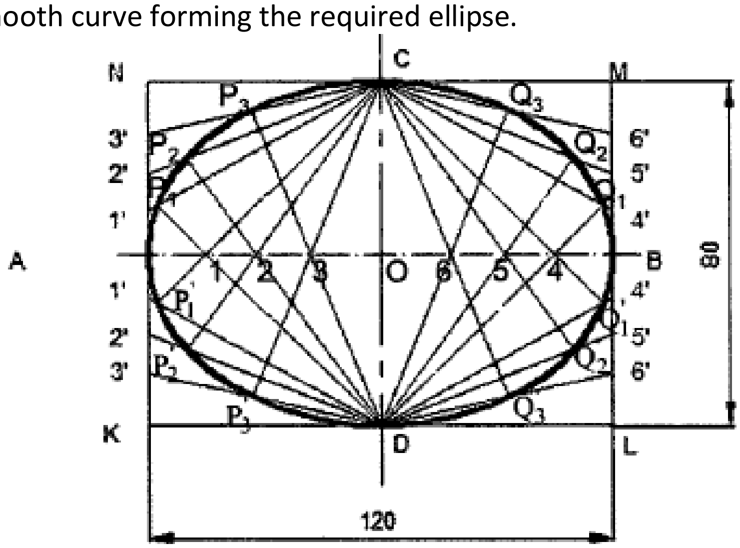


Fig. 1.22 Ellipse by Oblong Method

Parabola

Various Methods of construction of Parabola

a) General Method
b) Rectangle method
c) Tangent Method

a) General Method

Problem: To draw a normal and tangent through a point 40 mm from the directrix.
To draw a tangent and normal to the parabola, locate the point M which is at 40 mm from the direct QX. Then join M to F and draw a line through F, perpendicular to MF to meet the directrix at T. The line joining T and M and extended is the tangent and a line NN, through M and perpendicular to TM is the normal to the curve.

Following are the details of drawing different conic sections with the help of general or eccentricity method.
1. Draw the axis AB and the directrix CD at right angles to it:
2. Mark the focus F on the axis at 50mm.
3. Locate the vertex V on AB such that AV = VF
4. Draw a line VE perpendicular to AB such that VE = VF\
5. Join A, E and extend. Now, VENA = VFNA = 1, the eccentricity.
6. Locate number of points 1, 2, 3, etc., to the right of V on the axis, which need not be equidistant.
7. Through the points 1,2,3, etc., draw lines perpendicular to the axis and to meet the line AE extended at 1',2',3' etc.
8. With centre F and radius 1-1'draw arcs intersecting the line through I at P I and P'1'.
9. Similarly, locate the points P_2 etc., on either side of the axis. Join the points by smooth curve, forming the required parabola.

To draw a normal and tangent through a point 40 mm from the directrix

To draw a tangent and normal to the parabola, locate the point M which is at 40 mm from the direct QX. Then join M to F and draw a line through F, perpendicular to MF to meet the directrix at T. The line joining T and M and extended is the tangent and a line NN, through M and perpendicular to TM is the normal to the curve.

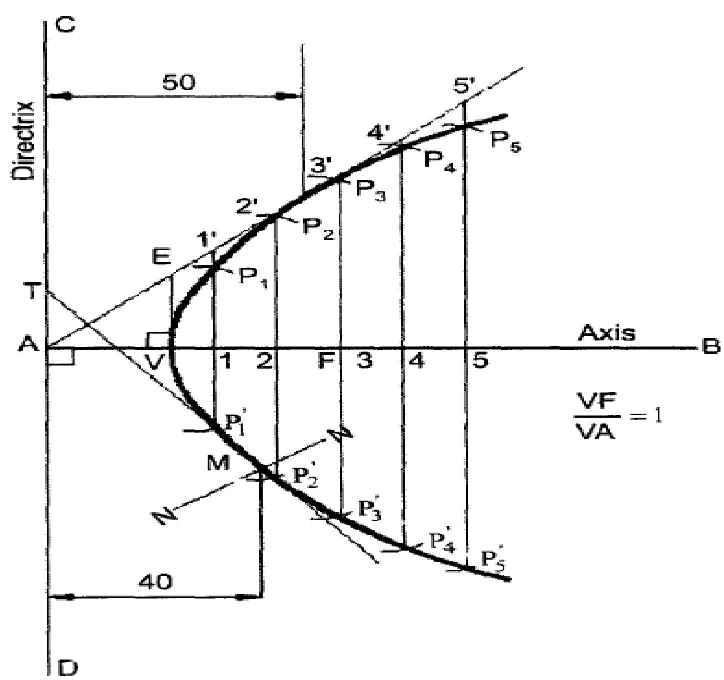


Fig. 1.23 Parabola by General Method

b) Rectangle method

Following are the steps of drawing parabola with the help of rectangle method.

1. Draw the base AB and axis CD such that CD is perpendicular bisector to AB.
2. Construct a rectangle ABEF, passing through C.
3. Divide AC and AF into the same number of equal parts and number the points 'as shown.
4. Join 1,2 and 3 to D.
5. Through 1',2' and 3', draw lines parallel to the axis, intersecting the lines ID, 2D and 3D at PI' P 2 and P3 respectively.
6. Obtain the points P;, P~ and P~, which are symmetrically placed to PI' P2 and P3 with respect to the axis CD.
7. Join the points by a smooth curve forming the required parabola.

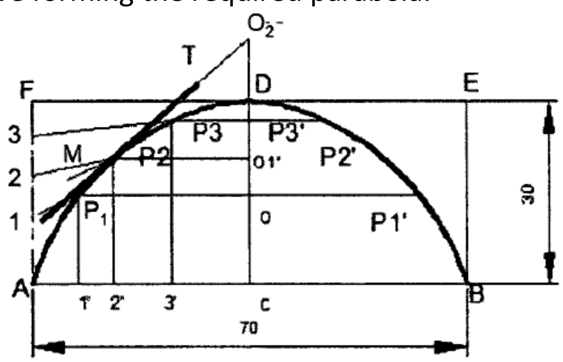


Fig. 1.24 Parabola by Rectangle Method

b) Tangent Method

Problem: To draw a parabola with 70 mm as base and 30 mm as the length of the axis.

Construction:

Following are the steps of drawing parabola with the help of tangent method.

1. Draw the base AB and locate its mid-point C.
2. Through C, draw CD perpendicular to AB forming the axis.
3. Produce CD to E such that DE = CD.
4. Join E-A and E-B. These are the tangents to the parabola at A and B.
5. Divide AE and BE into the same number of equal parts and number the points as shown.
6. Join 1-1’, 2- 2’, 3- 3’, etc., forming the tangents to the required parabola.
7. A smooth curve passing through A, D and B and tangential to the above lines is the required parabola.
8. To draw a tangent to the curve at a point, say M on it, draw a horizontal through M, meeting the axis at F. mark G on the extension of the axis such that DG = FD. Join G, M and extend, forming the tangent to the curve at M.

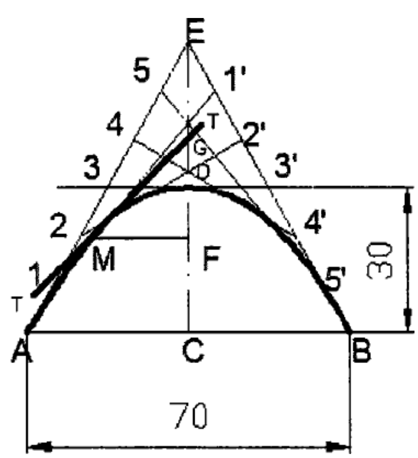


Fig. 1.25 Parabola by Tangent Method

Hyperbola

Various Method of construction of Hyperbola

a) General Method

b) Focus Vertex Method

a) General Method

Problem: Draw a hyperbola with eccentricity equal to 3/2 for the above problem**.**

Construction: Following are the details of drawing different conic sections with the help of general or eccentricity method.

1. Draw the axis AB and the directrix CD at right angles to it:
2. Mark the focus F on the axis at 50mm.
3. Locate the vertex V on AB such that AV = VF
4. Draw a line VE perpendicular to AB such that VE = VF\
5. Join A, E and extend. Now, VENA = VFNA = 1, the eccentricity.
6. Locate number of points 1, 2, 3, etc., to the right of V on the axis, which need not be equidistant.
7. Through the points 1,2,3, etc., draw lines perpendicular to the axis and to meet the line AE extended at 1',2',3' etc.
8. With centre F and radius 1-1'draw arcs intersecting the line through I at P I and P'1'.
9. Similarly, locate the points P_2 etc., on either side of the axis. Join the points by smooth curve, forming the required hyperbola.

To draw a normal and tangent through a point 40 mm from the directrix

To draw a tangent and normal to the parabola, locate the point M which is at 40 mm from the direct QX. Then join M to F and draw a line through F, perpendicular to MF to meet the directrix at T. The line joining T and M and extended is the tangent and a line NN, through M and perpendicular to TM is the normal to the curve.

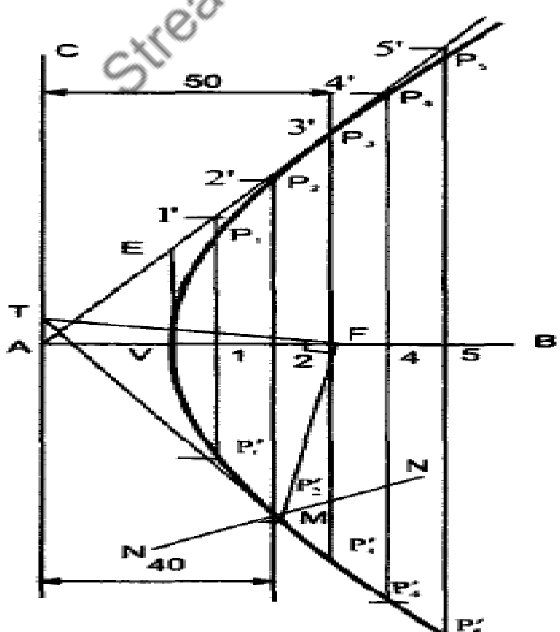


Fig. 1.26 Hyperbola by General Method

b) Focus Vertex Method---

Problem: Construct a hyperbola with its foci 70 mm apart and the major axis (distance between the vertices) as 40 mm. Draw a tangent to the curve at a point 20 mm from the focus.

Construction: Following are the steps of drawing a hyperbola.

1. Draw the transverse and conjugate axes AB and CD of the hyperbola and locate F I and F 2' the foci and V I and V Z' the vertices.
2. Mark number of points 1, 2, 3 etc., on the transverse axis, which need not be equi-distant.
3. With centre F1 and radius $V_1 1$, draw arcs on either side of the transverse a.xis.
4. With centre F2 and radius $V_2 1$, draw arcs intersecting the above arcs at P_1 and P_1'.
5. With centre F2 and radius $V_1 1$, draw arcs on either side of the transverse axis.
6. With centre F1 and radius $V_2 1$, draw arcs intersecting the above arcs at Q_1, Q_1'.
7. Repeat the steps 3 to 6 and obtain other points P_2, P_2' etc. and Q_2, Q_2' etc.
8. Join the points P_1, P_2, P_3, P_1', P_2', P_3' and Q_1, Q_2, Q_3, Q_1', Q_2', Q_3' forming the two branches of hyperbola.

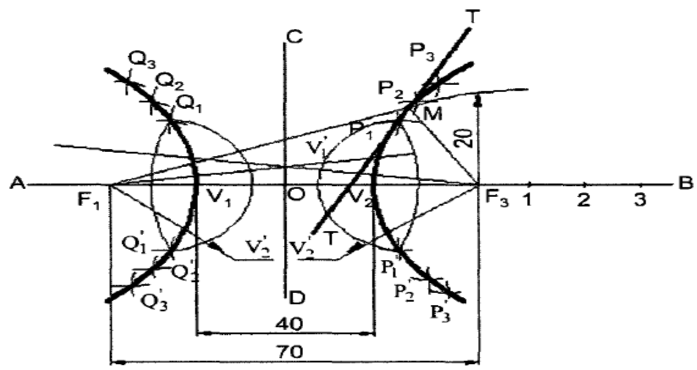


Fig. 1.27 Construction of Hyperbola

To draw the asymptotes to the given hyperbola

Lines passing through the centre and tangential to the curve at infinity are known as asymptotes.

Construction

1. Through the vertices V_1 and V_2 draw perpendiculars to the transverse axis.
2. With centre ° and radius $OF_1 = (OF_2)$, draw a circle meeting the above lines at P, Q and R, S.
3. Join the points P, O, R and S, O, Q and extend, forming the asymptotes to the hyperbola.

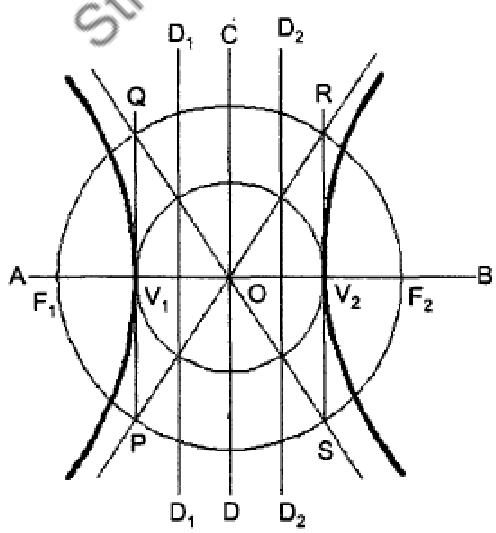


Fig. 1.28 Drawing asymptotes to a hyperbola

Rectangular Hyperbola

When the asymptotes to the hyperbola intersect each other at right angles, the curve is known as a rectangular hyperbola.

Problem: Construct a rectangular hyperbola when a point P on it is at a distance of 30 mm and 40 mm respectively from the two asymptotes.

Construction:

1. For a rectangular hyperbola, angle between the asymptotes is 90°. So, draw OR_1 and OR_2 such that the angle R_1OR_2 is 90°.
2. Mark A and B along OR_2 and OR_1 respectively such that OA = 40 mm and OB = 30 mm. From A draw AX parallel to OR_1 and from B draw BY parallel to OR_2. Both intersect at P.
3. Along BP mark 1, 2, and 3 at approximately equal intervals. Join O_1, O_2, and O_3 and extend them to meet AX at 1_1, 2_1 and 3_1 respectively.
4. From 1_1 draw a line parallel to OR_2 and from 1 draw a line parallel to OR_1. From 2 and 3 draw lines parallel to OR_1. They intersect at P_2 and P_3 respectively.
5. Then along PA mark points 4_1 and 5_1 at approximately equal intervals. Join $O4_1$ and $O5_1$ and extend them to meet BY at 4 and 5 respectively.
6. From 4_1 and 5_1 draw lines parallel to OR_2 and from 4 and 5 draw lines parallel to OR_1 to intersect at P_4 and P_5 respectively
7. Join P_1, P_2, P_3, P, P_4, and P_5 by smooth rectangular hyperbola.

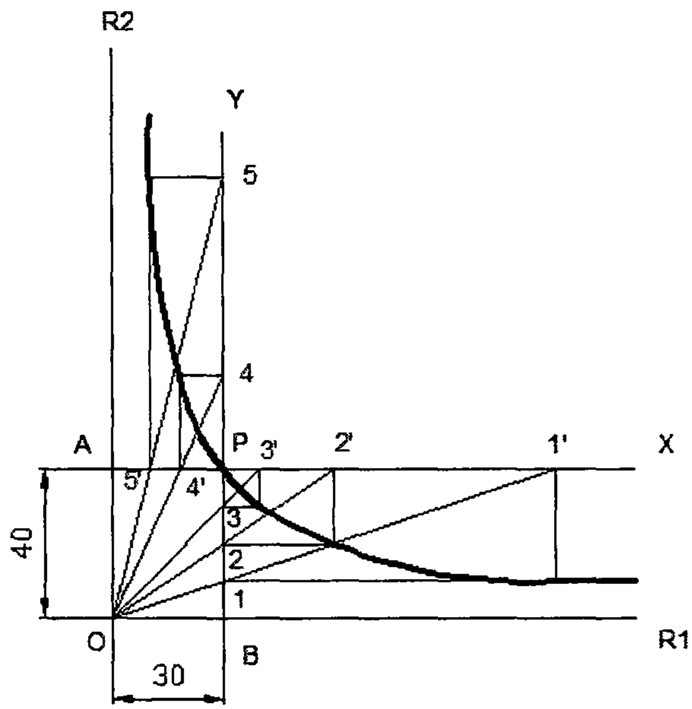


Fig. 1.29 Rectangular Hyperbola

Special Curves (Engineering Curves):

Cycloidal Curves

Cycloidal curves are generated by a fixed point in the circumference of a circle when it rolls without slipping along a fixed straight line or circular path. The rolling circle is called the generating circle, the fixed straight line, the directing line and the fixed circle, the directing circle.

1. Cycloid

A cycloid is a curve generated by a fixed point on the circumference of a circle, when it rolls without slipping along a straight line.

Problem: To draw a cycloid, given the radius R of the generating circle.

Construction

1. With centre ° and radius R, draw the given generating circle.
2. Assuming point P to be the initial position of the generating point, draw a line PA, tangential and equal to the circumference of the circle.
3. Divide the line PA and the circle into the same number of equal parts and number the points.

4. Draw the line OB, parallel and equal to PA. OB is the locus of the centre of the generating circle.
5. Erect perpendiculars at 1’, 2’, 3’, etc., meeting OB at O_1, O_2, O_3 etc.
6. Through the points 1, 2, 3 etc., draw lines parallel to PA.
7. With centre 0, and radius R, draw an arc intersecting the line through 1 at P_1, P_1 is the position of the generating point, when the centre of the generating circle moves to °1,
S. Similarly locate the points P_2, P_3 etc.
9. A smooth curve passing through the points P, P_1, P_2, P_3 etc., is the required cycloid.

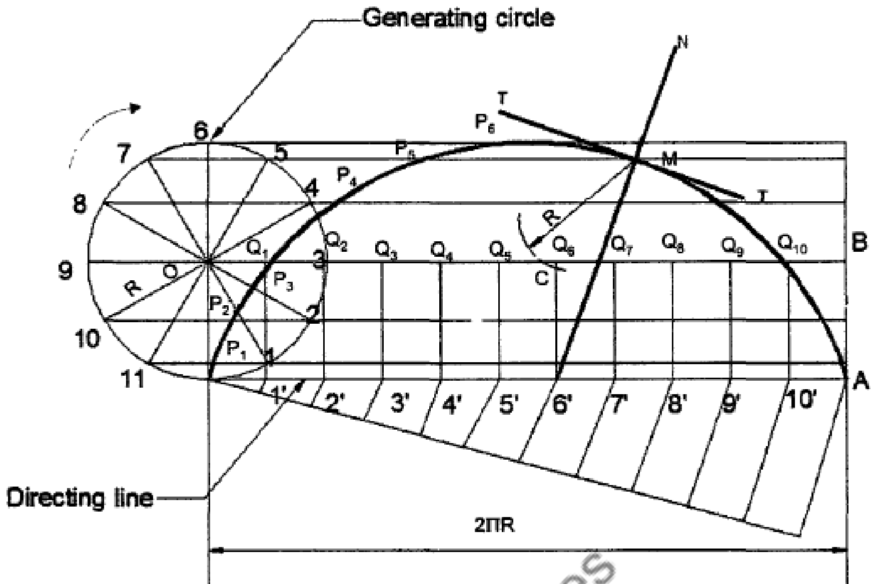


Fig. 1.30 Construction of a Cycloid

Epicycloid and Hypocycloid

An epi-cycloid is a curve traced by a point on the circumference of a generating circle, when it rolls without slipping on another circle (directing circle) outside it. If the generating circle rolls inside the directing circle, the curve traced by the point in called hypo-cycloid.

Problem: To draw an epicycloid, given the radius 'r' of the generating circle and the radius 'R' of the directing circle.

Construction:

1. With centre O' and radius R, draw a part of the directing circle.
2. Draw the generating circle, by locating the centre O of it, on any radial line O’P extended such that OP = r.
3. Assuming P to be the generating point, locate the point A on the directing circle such that the arc length PA is equal to the circumference of the generating circle. The angle subtended by the arc PA at O' is given by e = angle PO'A = 360° x r/R.
4. With centre O' and radius O'O, draw an arc intersecting the line O'A produced at B. The arc OB is the locus of the centre of the generating circle.
s. Divide the arc PA and the generating circle into the same number of equal parts and number the points.
6. Join O'-1', O'-2', etc., and extend to meet the arc OB at O_1, O_2 etc.
7. Through the points 1, 2, 3 etc., draw circular arcs with O' as centre.
8. With centre 0 1 and radius r, draw an arc intersecting the arc through 1 at P_1.
9. Similarly, locate the points P_2, P_3 etc.
10. A smooth curve through the points P_1, P_2, P_3 etc., is the required epicycloid.

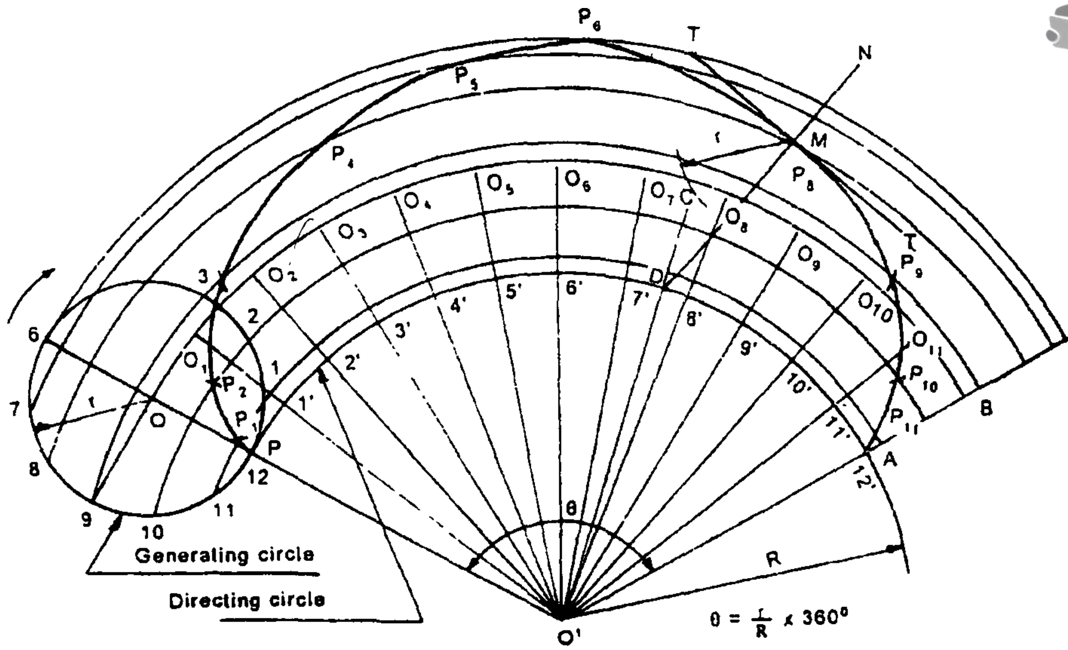


Fig. 1.31 Construction of an Epicycloid

Problem: Draw a hypocycloid of a circle of 40 mm diameter which rolls inside another circle of 200 mm diameter for one revolution. Draw a tangent and normal at any point on it.

Construction:

1. Taking any point 0 as centre and radius (R) 100 mm draw an arc PQ which subtends an angle e = 72° at O.
2. Let P be the generating point. On OP mark PC = r = 20 mm, the radius of the rolling circle.
3. With C as centre and radius r (20 mm) draw the rolling circle. Divide the rolling circle into 12 equal parts as 1, 2, 3 etc., in clock wise direction, since the rolling circle is assumed to roll counter clock wise.
4. With O as centre, draw concentric arcs passing through 1, 2, 3 etc.
5. With O as centre and OC as radius draw an arc to represent the locus of centre.
6. Divide the arc PQ into same number of equal parts (12) as 1', 2', 3' etc.
7. Join O_1', O_2' etc, which will intersect the locus of the centre at C_1, C_2, C_3 etc.
8. Taking centre C_1 and radius r, draw an arc cutting the arc through 1 at P_1. Similarly obtain the other points and draw a smooth curve through them.

To draw a tangent and normal at a given point M:

1. With M as centre and radius r = CP cut the locus of centre at the point N.
2. Join ON and extend it to intersect the base circle at S.
3. Join MS, the normal.
4. At M, draw a line perpendicular to MS to get the required tangent.

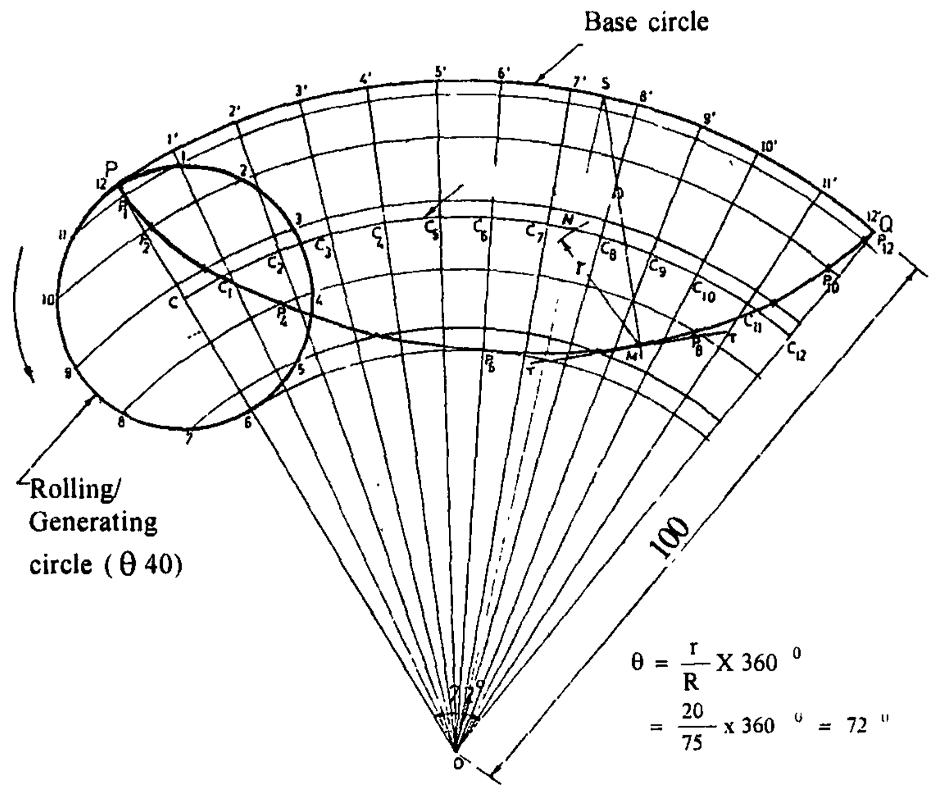


Fig. 1.32 Construction of a Hypocycloid

Involutes:

An involute is a curve traced by a point on a perfectly flexible string, while unwinding from around a circle or polygon the string being kept taut (tight). It is also a curve traced by a point on a straight line while the line is rolling around a circle or polygon without slipping.

Problem: To draw an involute of a given square.

Construction:

1. Draw the given square ABCD of side a.
2. Taking A as the starting point, with centre B and radius BA=a, draw an arc to intersect the line CB produced at P_1.
3. With Centre C and radius CP_1 =2 a, draw on arc to intersect the line DC produced at P_2.
4. Similarly, locate the points P_3 and P_4.

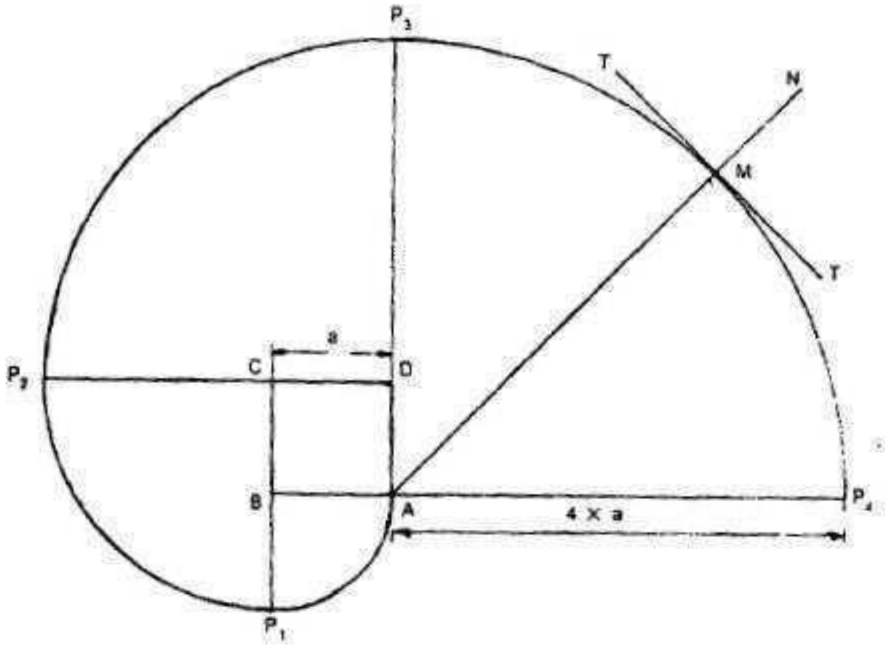


Fig. 1.33 Construction of an Involute of a Square

Problem: Draw an Involute of a circle of 50 mm diameter. Also draw Tangent and normal at a point distant 100 mm from the center of the circle.

Construction: 1) Point or end P of string AP is exactly πD distance away from A. Means if this string is wound round the circle, it will completely cover given circle. B will meet A after winding.

2) Divide πD (AP) distance into 8 numbers of equal parts.

3) Divide circle also into 8 numbers of equal parts.

4) Name after A, 1, 2, 3, 4, etc. up to 8 on πD line AP as well as on circle (in anticlockwise direction).

5) To radius C-1, C-2, C-3 up to C-8 draw tangents (from 1, 2, 3, 4, etc to circle).

6) Take distance 1 to P in compass and mark it on tangent from point 1 on circle (means one division less than distance AP).

7) Name this point P_1.

8) Take 2-B distance in compass and mark it on the tangent from point 2. Name it point P_2.

9) Similarly take 3 to P, 4 to P, 5 to P up to 7 to P distance in compass and mark on respective tangents and locate P_3, P_4, P_5 up to P_8 (i.e. A) points and join them in smooth curve it is an INVOLUTE of a given circle.

Involute Method of Drawing Tangent & Normal

1) Mark point q on it as directed.

2) Join q to the center of circle c. considering cq diameter, draw a semicircle as shown.

3) Mark point of intersection of this semicircle and pole circle and join it to q.

4) This will be normal to involute.

5) Draw a line at right angle to this line from q.

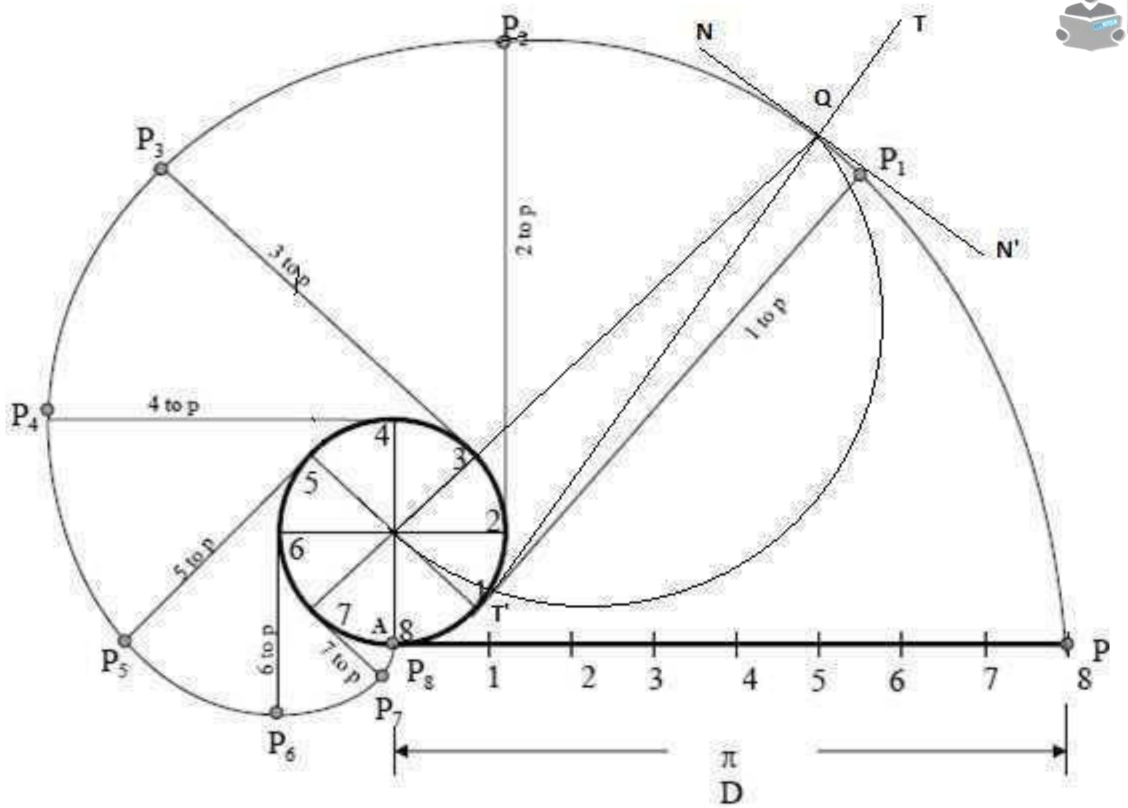


Fig. 1.34 Construction of an Involute of a Circle

Spirals:
If a line rotates in a plane about one of its end and at the same time, if a point moves along the line continuously in one direction, the curve traced out by the moving point is called Spiral.
Terminologies used in spirals are as follows:
1. Pole: Fixed end of the line about which the line rotates.
2. Radius Vector: The line joining any point of the curve with the pole.
3. Vectorial Angle: Angle between the initial position of the line and the instantaneous position of the line.
4. Convolution: Rotation of the moving line through 360 is called one convolution. A spiral make any number of convolution before it reaches the final destination.

Types of Spiral
1. Archimedean Spiral: An Archimedean Spiral is a curve traced out by a point moving uniformly along a straight line towards or away from the pole, while the line revolves about its one of the ends with uniform angular velocity.
Problem: Construct an Archimedean spiral for one and half convolution. The greatest and the least radii being 50 mm and 14 mm respectively. Draw tangent and normal to the spiral at a point 40 mm from the center.
Construction:
1) Draw a horizontal axis of the length equal to 100 mm. And mark the center point O on it.
2) Draw a vertical axis bisecting and perpendicular to the horizontal axis passing through the point O.
3) With O as center and radii equal to 50 mm and 14 mm respectively draw two circles.
4) Divide these circles into 12 equal divisions. And give the notations 0, 1, 2, 3, etc. up to 18 because of one and half convolution of the curve as shown into the figure.
5) Now divide the distance between the two circles, which is 50 mm – 14 mm = 36mm, on the horizontal axis into the same number of division as of the circle, which is 18 because of one and half convolution. So, the distance between the two consecutive divisions is 2 mm.
6) With O as center and radius equal to O1 on the horizontal axis draw an arc between the respective divisional lines of the circle OO & O1 as per the figure given above. Like in the same way draw 18 arcs.

7) Draw a smooth medium dark free hand curve from the end points of the previously drawn arcs in sequence to get Archimedean Curve.

8) To draw normal and tangent to the curve mark a point say K to the curve at the given distance which is 40 mm form the center O by a compass. Draw a line starting from this point K to the center of the circle O. With this line KO draw a perpendicular line of the length equal to value of the formula given below:

X = Distance between the two radius vectors in mm/ Difference of these two radius vectors in radians.

Here it is selected as OO – O3, which is equal to 3.81 mm. Now from the end point of this line draw a medium dark line which passes through the point K, that is normal to the curve. And draw a perpendicular line to the normal and passing through the point K which is tangent to the curve.

9) Give the dimensions by any one method of dimensions and give the name of the components by leader lines wherever necessary.

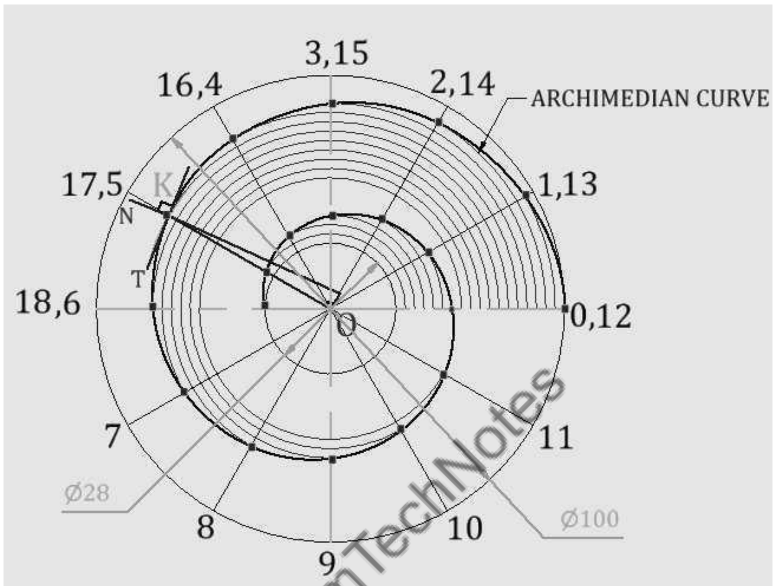


Fig. 1.35 Construction of an Archimedean Spiral

2. Logarithmic Spiral*:* The ratio of the lengths of consecutive radius vectors enclosing equal angles is always constant. I.e. the values of the vectorial angles are in arithmetic progression and the corresponding values of radius vectors are in geometric progression.

Problem: Ratio of lengths of radius vectors enclosing angle of 30° = 5:6. Final radius vector of the spiral is 90 mm. Draw the spiral.

Construction:

1. Draw line AB and AC inclined at 30°.
2. On line AB, mark A -12 = 90 mm. A as center and A12 radius draw an arc to cut AC at 12‘.
3. Mark A11 (= 5/6 of A12) on AB. Join 12‘ and 11.
4. Draw an arc with A as center and A11 radius to cut the line AC at 11‘.
5. Draw a line through 11‘ parallel to 12‘-11 to cut AB at 10. Repeat the procedure to obtain points 9‘, 8’, and 7‘…0.

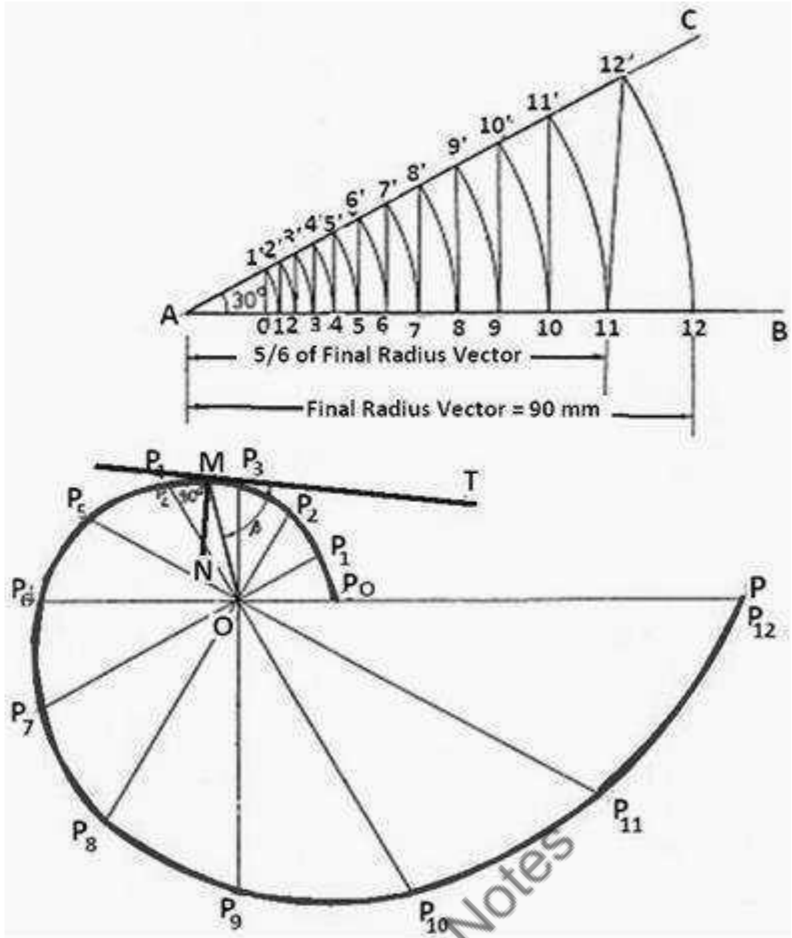


Fig. 1.36 Construction of an Logarithmic Spiral

Module – II

Orthographic Projections covering, Principles of Orthographic Projections - Conventions - Projections of Points and lines inclined to both planes; Projections of planes inclined Planes – Auxiliary Planes

Projection:

Any object has three dimensions, viz., length, width and thickness. A projection is defined as a representation of an object on a two dimensional plane. The projections of an object should convey all the three dimensions, along with other details of the object on a sheet of paper.

Types of Projections

1. Pictorial projections
(i) Perspective projection
(ii) Isometric projection
(iii) Oblique projection
2. Orthographic Projections

1. Pictorial Projections

The Projections in which the description of the object is completely understood in one view is known as pictorial projection. They have the advantage of conveying an immediate impression of the general shape and details of the object, but not its true dimensions or sizes.

2. Orthographic Projection

'ORTHO' means right angle and orthographic means right angled drawing. When the projectors are perpendicular to the plane on which the projection is obtained, it is known as orthographic projection.

Method of Obtaining Front View

Imagine an observer looking at the object from an infinite distance (Fig. 2.1). The rays are parallel to each other and perpendicular to both the front surface of the object and the plane. When the observer is at a finite distance from the object, the rays converge to the eye as in the case of perspective projection. When the observer looks from the front surface F or the block, its true shape and size is seen. When the rays or projectors are extended further they meet the vertical plane (V.P) located behind the object. By joining the projectors meeting the plane in correct sequence the Front view (Fig. 2.1) is obtained.

Front view shows only two dimensions of the object, Viz. length L and height H. It does not show the breadth B. Thus one view or projection is insufficient for the complete description of the object.

As Front view alone is insufficient for the complete description of the object, another plane called Horizontal plane (H.P) is assumed such that it is hinged and perpendicular to Y.P and the object is in front of the Y.P and above the H.P as shown in Fig. 2.1.

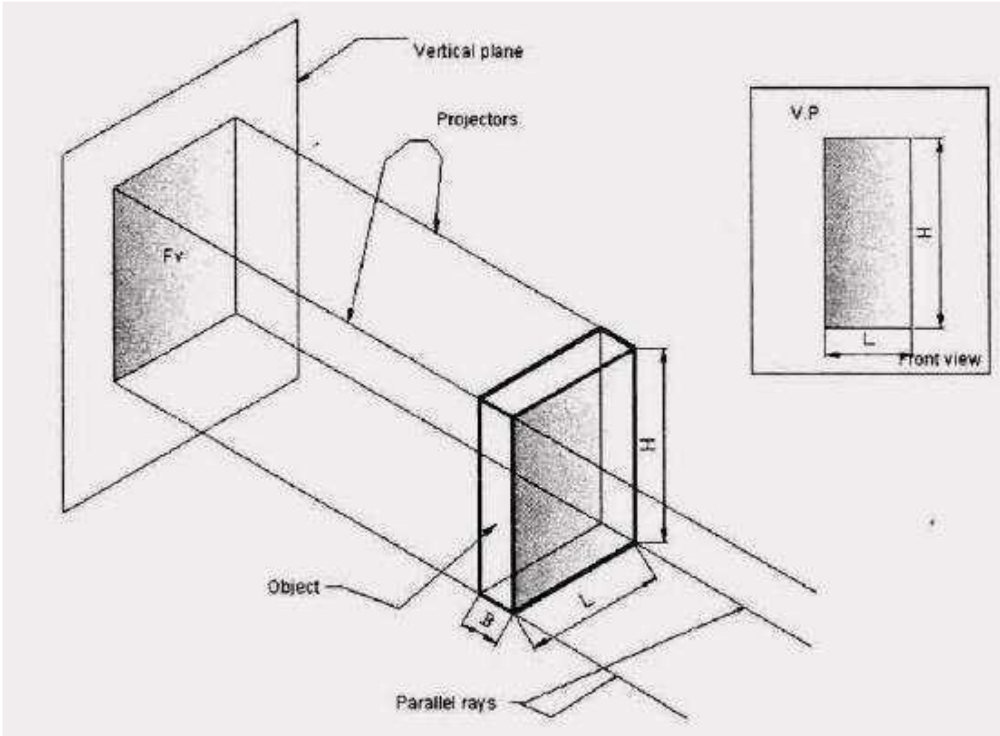


Fig. 2.1 Method of Obtaining Orthographic Front View

Method of Obtaining Top View
Looking from the top, the projection of the top surface is the Top view (TV). Both top surface and Top view are of exactly the same shape and size. Thus, Top view gives the True length L and breadth B of the block but not the height H.

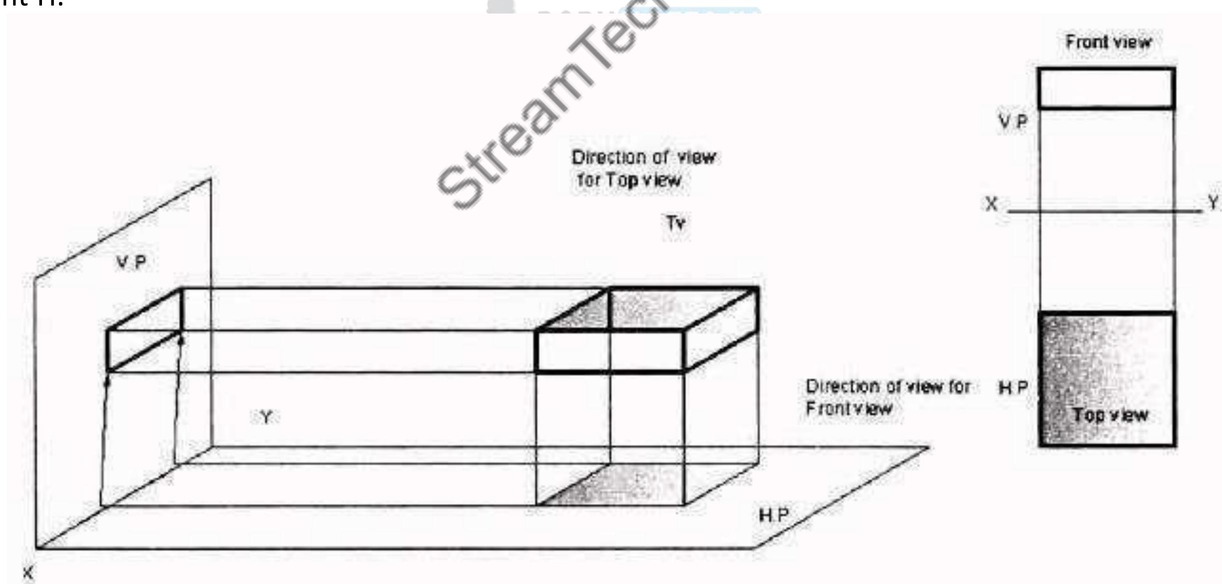


Fig. 2.2 Method of Obtaining Orthographic Top View

XY Line: The line of intersection of VP and H.P is called the reference line and is denoted as XY.

Obtaining the Projection on the Drawing Sheet
It is convention to rotate the H.P through 900 in the clockwise direction about XY line so that it lies in the extension of V.P. as shown in Fig. 2.2 a. The two projections Front view and Top view may be drawn on the two dimensional drawing sheet as shown in Fig. 2.2 b.
Thus, all details regarding the shape and size, Viz. Length (L), Height (H) and Breadth (B) of any object may be represented by means of orthographic projections i.e., Front view and Top view.

Terms Used

VP and H.P are called as Principal planes of projection or reference planes. They are always transparent and at right angles to each other. The projection on VP is designated as Front view and the projection on H.P as Top view.

Four Quadrants

When the planes of projections are extended beyond their line of intersection, they form Four Quadrants. These quadrants are numbered as I, II, ill and IV in clockwise direction when rotated about reference line XY as shown in Fig. 2.3.

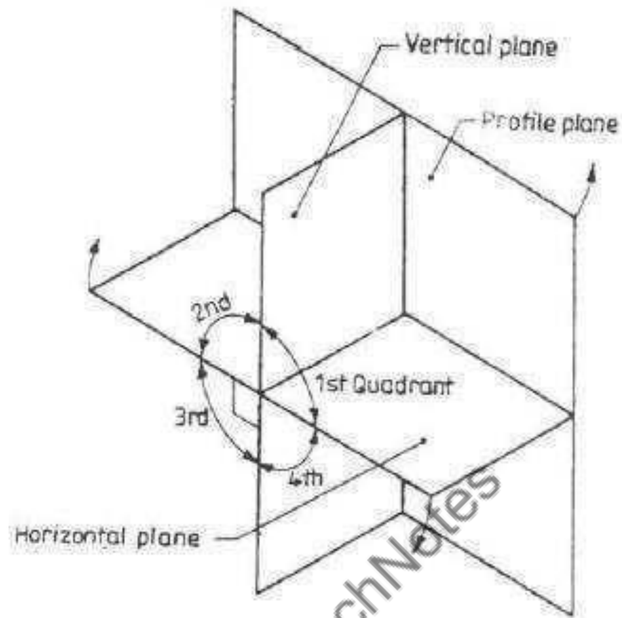


Fig. 2.3 Four Quadrants

In the Figure 2.4 the object is in the first quadrant and the projections obtained are "First angle projections" i.e., the object lies in between the observer and the planes of projection. Front view shows the length (L) and height (H) of the object, and Top view shows the length (L) and the breadth (B) of it.

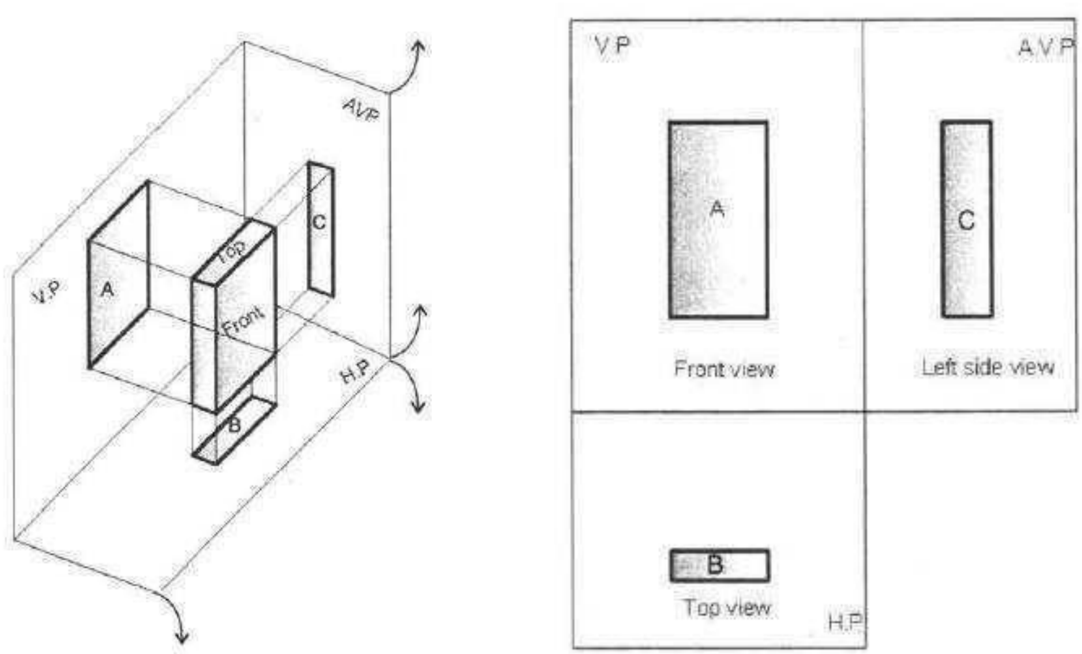


Fig. 2.4 Orthographic Projection of Front, Top and Side views

The object may be situated in anyone of four quadrants, its position relative to the planes being described as in front of V.P. and above H.P. in the first quadrant and so on.
Figure shows the two principle planes H.P and V.P. and another Auxiliary vertical plane (AVP). AVP is perpendicular to both V.P. and H.P. Front view is drawn by projecting the object on the V.P. Top view is drawn by projecting the object on the H.P. The projection on the AVP as seen from the left of the object and drawn on the right of the front view is called left side view.

First Angle Projection

When the object is situated in First Quadrant, that is, in front of V.P. and above H.P., the projections obtained on these planes are called First angle projection.
(i) The object lies in between the observer and the plane of projection.
(ii) The front view is drawn above the XY line and the top view below XY. (Above XY line is V.P. and below XY line is H.P.).
(iii) In the front view, H.P coincides with XY line and in top view V.P. coincides with XY line.
(iv) Front view shows the length (L) and height (H) of the object and Top view shows the length (L) and breadth (B) or width (W) or thickness (T) of it.

Third Angle Projection

In this, the object is situated in Third Quadrant. The Planes of projection lie between the object and the observer. The front view comes below the XY line and the top view about it.

Projection of Points

A solid consists of number of planes, a plane consists of a number of lines and a line in turn consists of number of points, from this, it is obvious that a solid may be generated by a plane.

Points in Space

A point may lie in space in anyone of the four quadrants. The positions of a point are:
1. First quadrant, when it lies above Horizontal Plane and in front of Vertical Plane.
2. Second quadrant, when it lies above Horizontal Plane and behind Vertical Plane.
3. Third quadrant, when it lies below Horizontal Plane and behind Vertical Plane.
4. Fourth quadrant, when it lies below Horizontal Plane and in front of Vertical Plane.

Convention

- Top views are represented by only small letters e.g. a.
- Their front views are conventionally represented by small letters with dashes e.g. a'
- Profile or side views are represented by small letters with double dashes e.g. a''
- The line of intersection of HP and VP is denoted as XY.
- The line of intersection of VP and PP is denoted as X_1Y_1
- Projectors and the lines of the intersection of planes of projections are shown as thin lines.

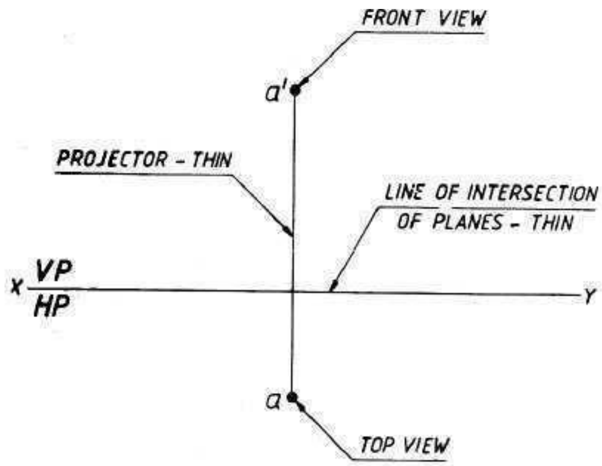
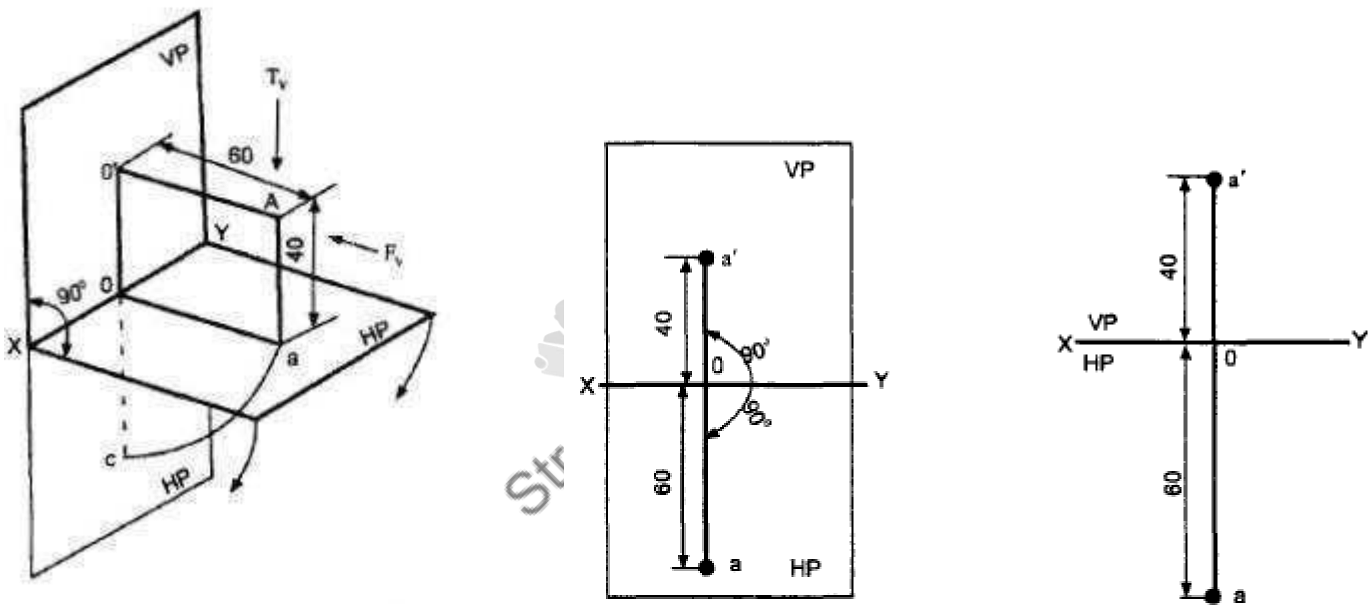


Fig. 2.5

Point in the First quadrant
Example: Point A is 40 mm above H.P. and 60 mm in front of V.P. Draw its front and top view.



(a) (b) (c)
Fig. 2.6

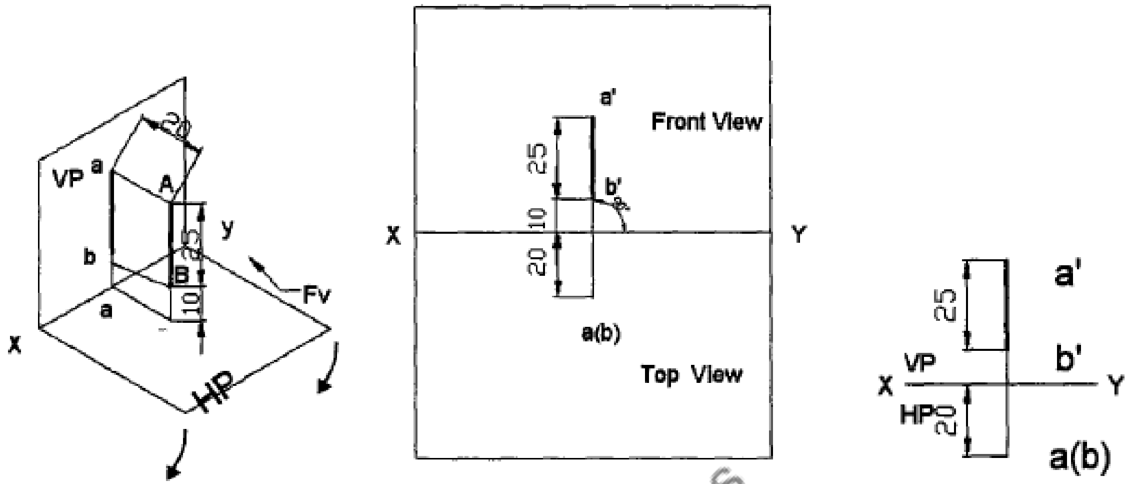
- Draw a thin horizontal line, XY, to represent the line of intersection of HP and VP.
- Draw the Top View (a) 60 mm below the XY line.
- Draw the projector line starts from ain vertical direction.
- Draw the Front View (a') 40 mm above the XY line.

Projection of Lines
The shortest distance between two points is called a straight line. The projectors of a straight line are drawn therefore by joining the projections of its end points. The possible projections of straight lines with respect to V.P and H.P in the first quadrant are as follows:
I. Perpendicular to one plane and parallel to the other.
2. Parallel to both the planes.
3. Parallel to one plane and inclined to the other.
4. Inclined to both the planes.

1. Line perpendicular to H.P and parallel to V.P

The pictorial view of a straight line AB in the First Quadrant is shown in Fig. 2.7 (a).

1. Looking from the front; the front view of AB, which is parallel to V.P. and marked, a’ b’, is obtained. True length of AB = a’ b’
2. Looking from the top; the top view of AB, which is perpendicular to H.P is obtained a and b coincide.
3. The Position of the line AB and its projections on H.P. and V.P. are shown in Fig. 2.7 (b).
4. The H.P is rotated through 900 in clock wise direction as shown in Fig. 2.7 (b).
5. The projection of the line on V.P which is the front view and the projection on H.P, the top view are shown in Fig. 2.7 (c).



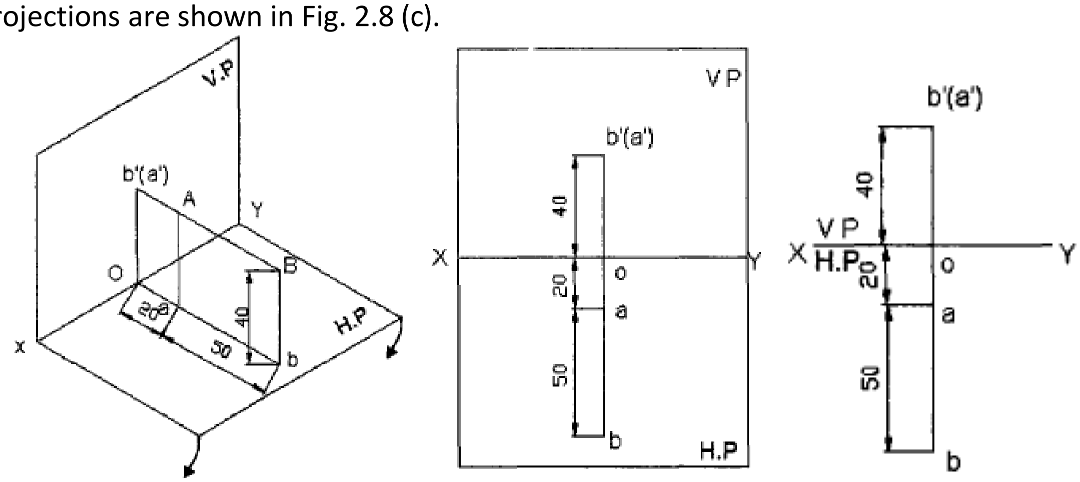
(a) (b) (c)

Fig. 2.7 Line perpendicular to H.P and parallel to V.P

2. Line perpendicular to V.P. and parallel to H.P.

The line is parallel to H.P. Therefore the true length of the line is seen in the top view. So, top view is drawn first.

1. Draw XY line and draw a projector at any point on it.
2. Point A is 20 mm in front of V.P. Mark a which is the top view of A at a distance of 20 mm below XY on the projector.
3. Mark the point b on the same projector at a distance of 50 mm below a. ab is the top view which is true length of AB.
4. To obtain the front view; mark b’ at a distance 40mm above XY line on the same projector.
5. The line AB is perpendicular to V.P. So, the front view of the line will be a point. Point A is hidden by B. Hence the front view is marked as b’ (a’). b’ coincides with a^{l} .
6. The final projections are shown in Fig. 2.8 (c).

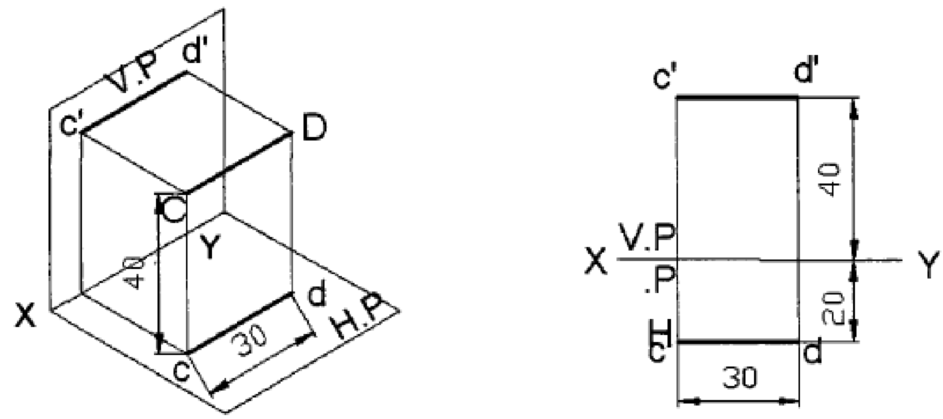


(a) (b) (c)

Fig. 2.8 Line perpendicular to V.P. and parallel to H.P.

3. Line parallel to both the planes

1. Draw the XY line and draw a projector at any point on it.
2. To obtain the front view mark c' at a distance of 40 mm above XY (H.P.). The line CD is parallel to both the planes. Front view is true length and is parallel to XY. Draw c'd' parallel to XY such that c'd' = CD = 30 mm, which is the true length.
3. To obtain the top view; the line is also parallel to V.P. and 20 mm in front of V.P. Therefore on the projector from c', mark c at distance 20 mm below XY line.
4. Top view is also true length and parallel to XY. Hence, cd parallel to XY such that cd = CD = 30 mm is the true length (Fig. 2.9).

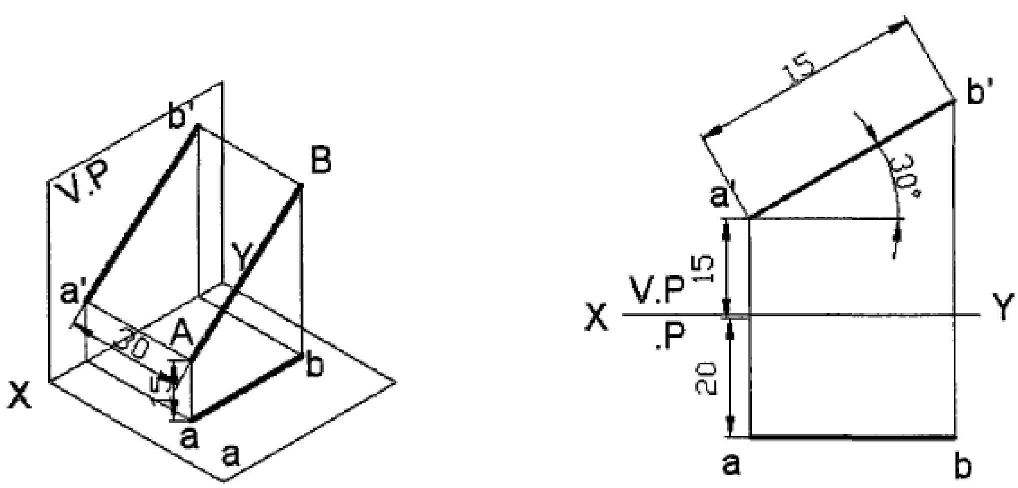


(a) (b)

Fig. 2.9 Line parallel to both the planes

4. Line parallel to V.P. and inclined to H.P.

1. A is 15 mm above H.P mark a', 15 mm above XY.
2. A is 20 mm in front of V.P. Hence mark a 20 mm below XY.
3. To obtain the front view a$^{|}$ b$^{|;}$ as AB is parallel to V.P and inclined at an angle a to H.P., a'b' will be equal to its true length and inclined at an angle of 30° to H.P. Therefore draw a line from a' at an angle 30° to XY and mark b' such that a'b' = 40 mm = true length.
4. To obtain the top view ab; since the line is inclined to H.P its projection on H.P (its top view) is reduced in length. From b' draw a projector to intersect the horizontal line drawn from a at b. ab is the top view of AB. Inclination of line with the H.P is always denoted as θ.



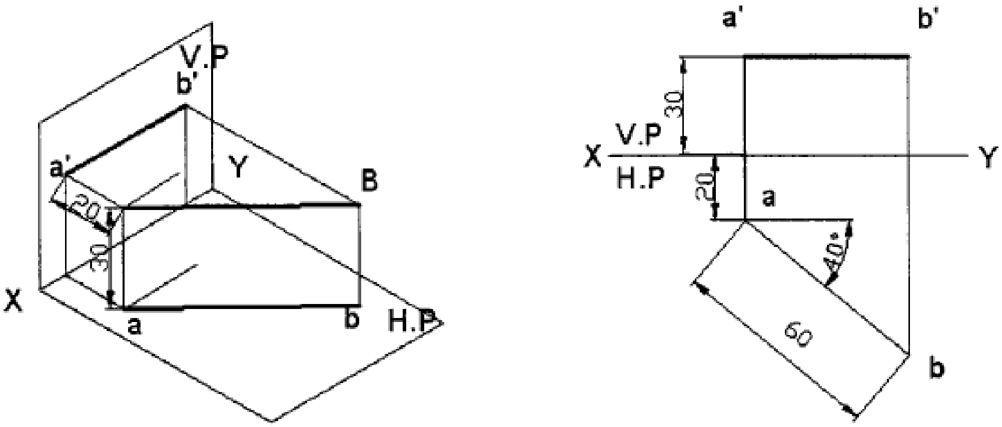
(a) (b)

Fig. 2.10 Line parallel to V.P. and inclined to H.P.

5. Line parallel to H.P. and inclined to V.P.

1. A is 30 mm above H.P, mark a', 30 mm above XY.
2. A is 20 mm in front of V.P., mark a 20 mm below XY.
3. To obtain the top view; as AB is parallel to H.P and inclined at an angle Φ to V.P, ab will be equal to the true length of AB, and inclined at angle Φ to XY. Therefore, draw a line from a at 40° to XY and mark b such that ab = 60 mm true length.
4. To obtain the front view a'b', since the line is inclined to V.P its projection on V.P. i.e., the front view will be reduced in length. Draw from b a projector to intersect the horizontal line drawn from a at bl. a'b' is the front view of AB.

Inclination of a line with V.P is always denoted by Φ.



(a) (b)

Fig. 2.11 Line parallel to H.P. and inclined to V.P.

6. Line inclined to both the planes

When a line is inclined to both H.P and V.P, it is called an oblique line. The solution to this kind of problem is obtained in three stages, as described below.

Stage I Assume the line is inclined to H.P by θ and parallel to V.P. (Fig. 2.12 b)

1. Draw the projections $a^lb^l_1$ and ab_1 of the line AB_l (=AB), after locating projections and a from the given position of the end A.

Keeping the inclination θ constant rotate the line AB_l to AB, till it is inclined at Φ° to V.P. This rotation does not change the length of the top view ab^l and the distance of the point B_l = (B) from H.P. Hence, (i) the length of ab_l is the final length of the top view and (ii) the line f-f, parallel to XY and passing through b_l^l is the locus of the front view of the end of point B.

Stage II Assume the line is inclined to VP by Φ° and parallel to H.P (Fig. 2.12 c)

2. Draw the projections ab2 and ab of the line AB_2 (=AB), after locating the projections a^l and a, from the given position of the end A.

Extending the discussion on the preceding stage to the present one, the following may be concluded. (i) The length ab is the final length of the front view and (ii) the line t-t, parallel to XY and passing through b_2 is the locus of the top view of the end point B.

Stage III Combine Stage I and Stage II (Fig. 2.12 d),

3. Obtain the final projections by combining the results from stage I and II as indicated below:

(i) Draw the projections $a^lb^l_1$ and ab_2 making an angle θ and Φ respectively with XY, after location of the projections a^l and a, from the given position of the end point A.

(ii) Obtain the projections $a^lb_2{}^l$ and ab^l, parallel to XY, by rotation.

(iii) Draw the lines f-f and t-t the loci parallel to XY and passing through b_l^l and b_2 respectively.

(iv) With centre a^l and radius $a^lb_2{}^l$, draw an arc meeting f-f at b^l.

(v) With centre a and radius ab_1, draw an arc meeting t-t at b.

(vi) Join a^l, b^l and a, b forming the required final projections. It is observed from the fig. 2.12 c that:

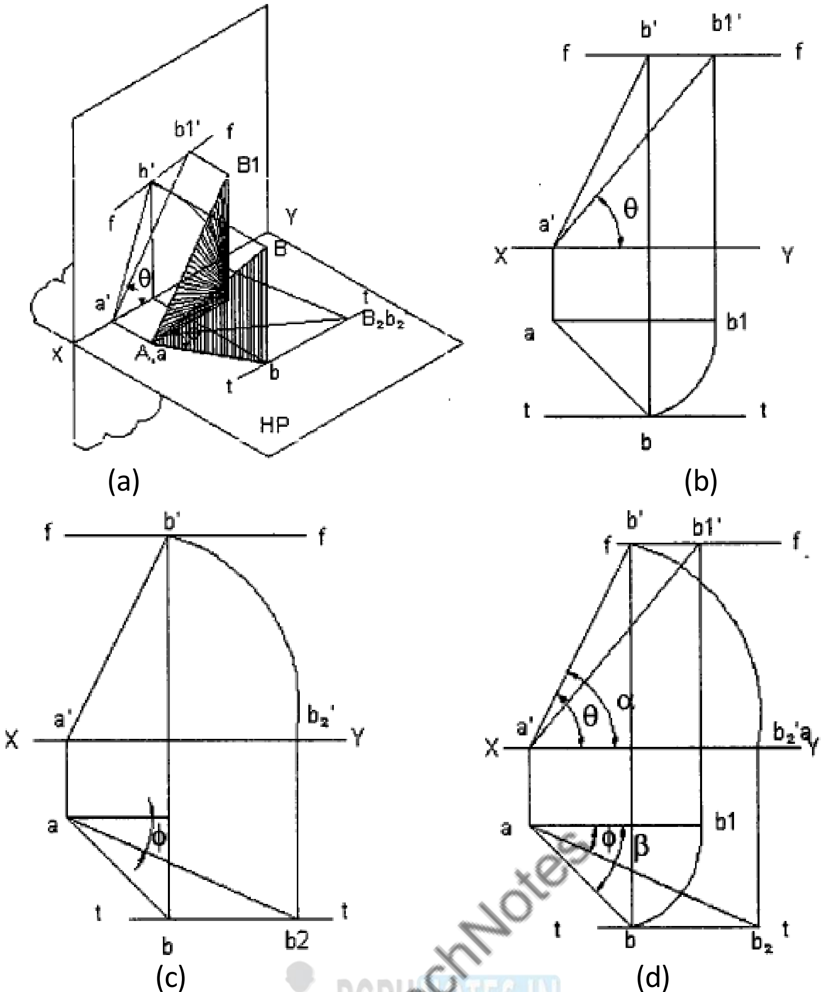


Fig. 2.12

To determine the true length of a line, given its projections - Rotating line method

In this, each view is made parallel to the reference line and the other view is projected from it. This is exactly reversal of the procedure adopted in the preceding construction.

Construction:

1. Draw the given projections a'b' and ab.
2. Draw f-f and t-t, the loci passing through b' and b and parallel to XY.
3. Rotate a'b' to $a'b_2'$, parallel to XY.
4. Draw a projector through b_2' to meet the line t-t at b_2.
5. Rotate ab_1 parallel to XY.
6. Draw a projector through b_1 to meet the line f-f at b_1'
7. Join a', b_1' and a, b_2.
8. Measure and mark the angles θ and Φ.

The length $a'b_1'$ (= ab_2) is the true length of the given line and the angles θ and Φ, the true inclinations of the line with H.P and V.P. respectively.

Projection of Planes

A plane figure has two dimensions viz. the length and breadth. It may be of any shape such as triangular, square, pentagonal, hexagonal, circular etc. The possible orientations of the planes with respect to the principal planes H.P. and V.P. of projection are:

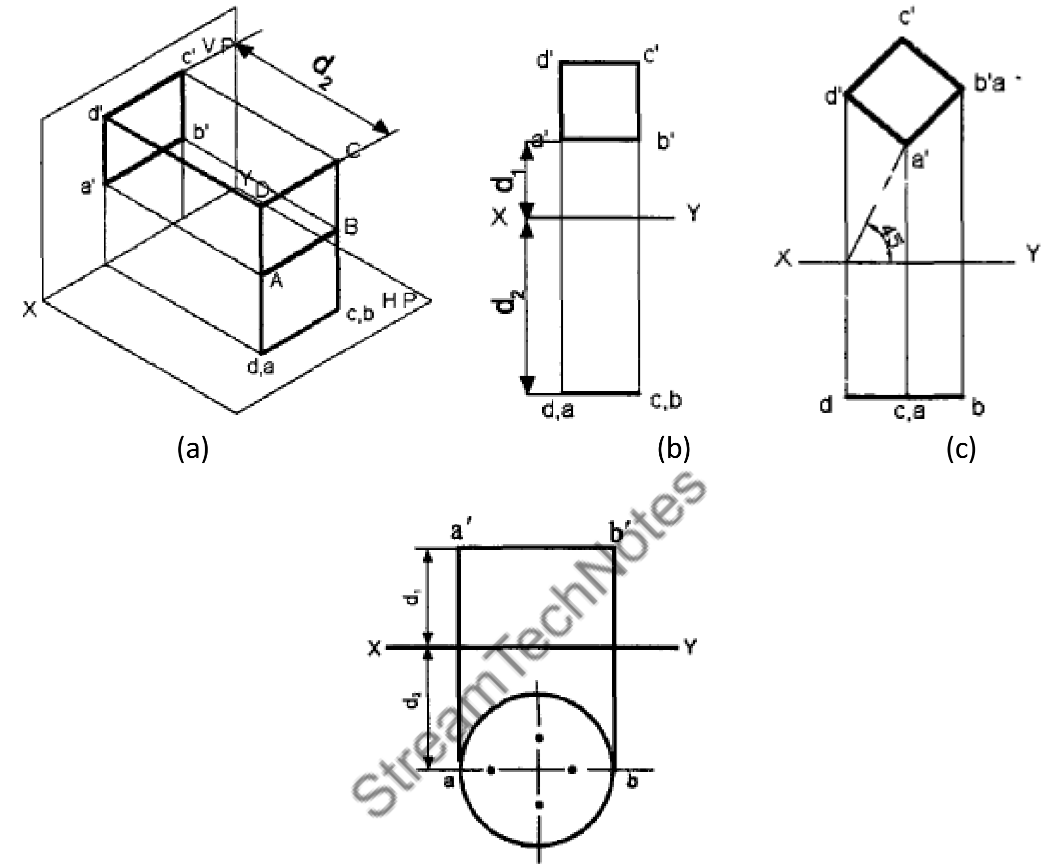
1. Plane parallel to one of the principal planes and perpendicular to the other,
2. Plane perpendicular to both the principal planes,
3. Plane inclined to one of the principal planes and perpendicular to the other,
4. Plane inclined to both the principal planes.

1. Plane parallel to one of the principal planes and perpendicular to the other:

When a plane is parallel to V.P the front view shows the true shape of the plane. The top view appears as a line parallel to XY. Fig. 2.13 (a) shows the projections of a square plane ABCD, when it is parallel to V.P. and perpendicular to H.P. The distances of one of the edges above H.P. and from the V.P. are denoted by d_1 and d_2 respectively.

Fig. 2.13 (b) shows the projections of the plane. Fig. 2.13 (c) shows the projections of the plane, when its edges are equally inclined to H.P.

Fig. 2.13 (d) shows the projections of a circular plane, parallel to H.P and perpendicular to V.P.



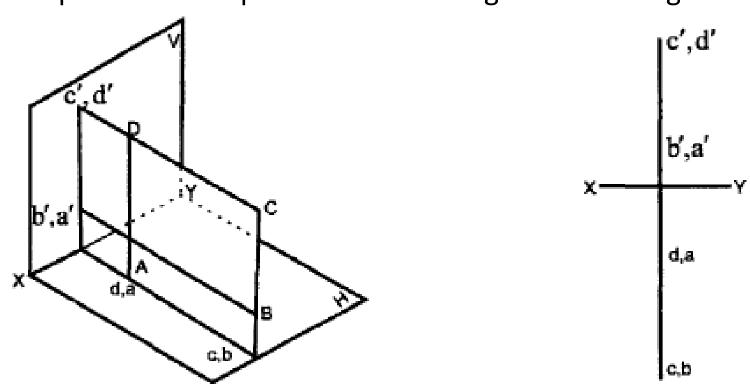
(a) (b) (c)

(d)

Fig. 2.13

2. Plane perpendicular to both H.P and V.P.

When a plane is perpendicular to both H.P. and V.P, the projections of the plane appear as straight lines. Fig. 2.14 shows the projections of a rectangular plane ABCD, when one of its longer edges is parallel to H.P. Here, the lengths of the front and top views are equal to the true lengths of the edges.



(a) (b)

Fig. 2.14

3. Plane inclined to one of the principal planes and perpendicular to the other

a) Plane inclined to H.P. and perpendicular to V.P.:

When a plane is inclined to one plane and perpendicular to the other, the projections are obtained in two stages.

Problem: Projections of a pentagonal plane ABCDE, inclined at θ to H.P and perpendicular to V.P. and resting on one of its edges on H.P.

Construction:

Stage 1 Assume the plane is parallel to H.P (lying on H.P) and perpendicular to V.P.

1. Draw the projections of the pentagon ABCDE, assuming the edge AE perpendicular to V.P. a'e' $b_1'd_1'c_1'$ on XY is the front view and $ab_1c_1d_1e$ is the top view.

Stage II Rotate the plane (front view) till it makes the given angle with H.P.

2. 'otate the front view till it makes the given angle θ with XY which is the final front view.

3. Obtain the final top view abcde by projection.

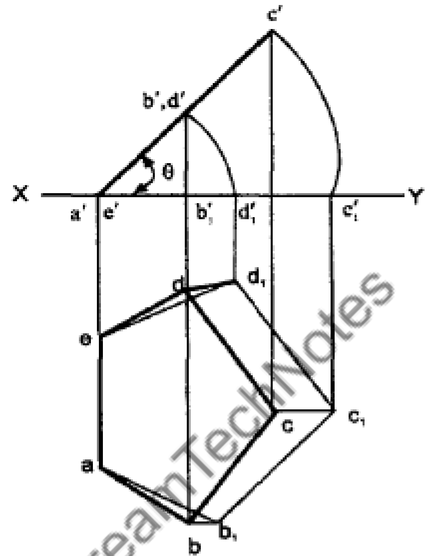


Fig. 2.15 Plane inclined to H.P. and perpendicular to V.P.

b) Plane inclined to V.P. and perpendicular to H.P.:

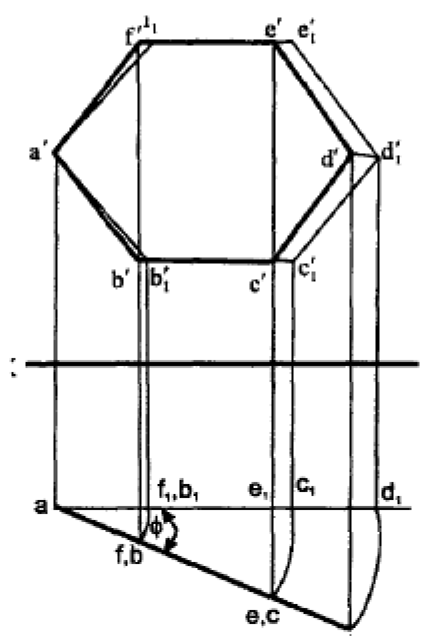


Fig. 2.16 Plane inclined to V.P. and perpendicular to H.P.

4. Plane inclined to both H.P and V.P

If a plane is inclined to both H.P and V.P, it is said to be an oblique plane. Projections of oblique planes are obtained in three stages.

Construction:

Stage I: Assume the plane is parallel to H.P and a shorter edge of it is perpendicular to V.P.

1. Draw the projections of the plane.

Stage II: Rotate the plane till it makes the given angle with H.P.

2. Redraw the front view, making given angle θ with XY and then project the top view.

Stage III: Rotate the plane till its shorter edge makes the given angle Φ with V.P.

3. Redraw the top view abed such that the shorter edge ad is inclined to XY by Φ.
4. Obtain the final front view $a_l b_l c_l d_l$, by projection.

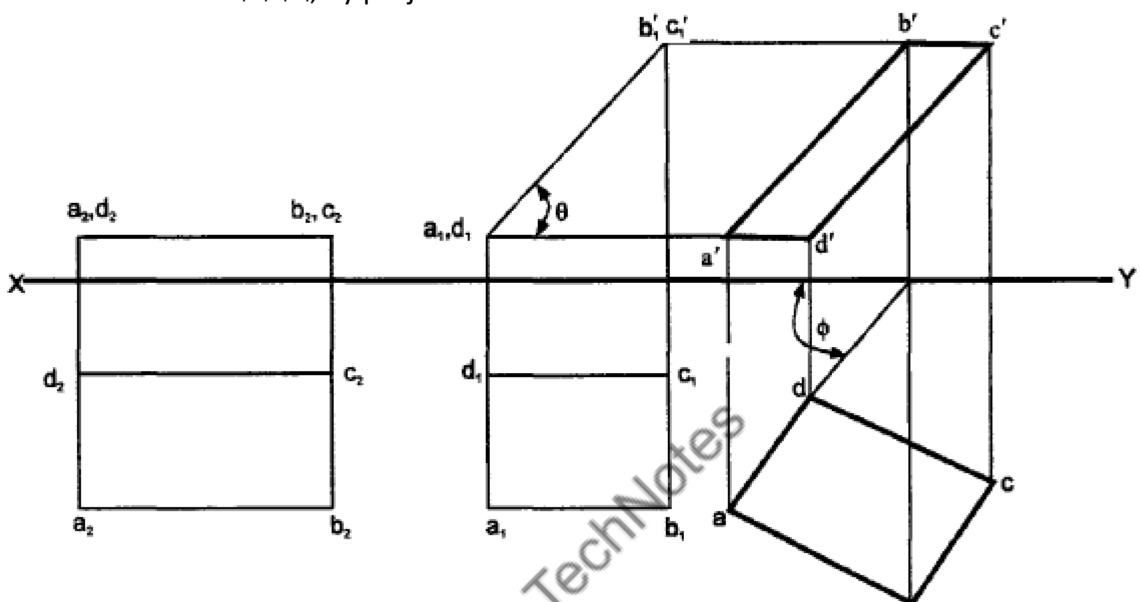


Fig. 2.17 Plane inclined to both the planes

Module - III

Projections of Regular Solids covering, those inclined to both the Planes- Auxiliary Views; Draw simple annotation, dimensioning and scale. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

Solid:

A solid has three dimensions, the length, breadth and thickness or height. A solid may be represented by orthographic views, the number of which depends on the type of solid and its orientation with respect to the planes of projection. Solids are classified into two major groups. (i) Polyhedra and (ii) Solids of revolution

Classification of Solids:

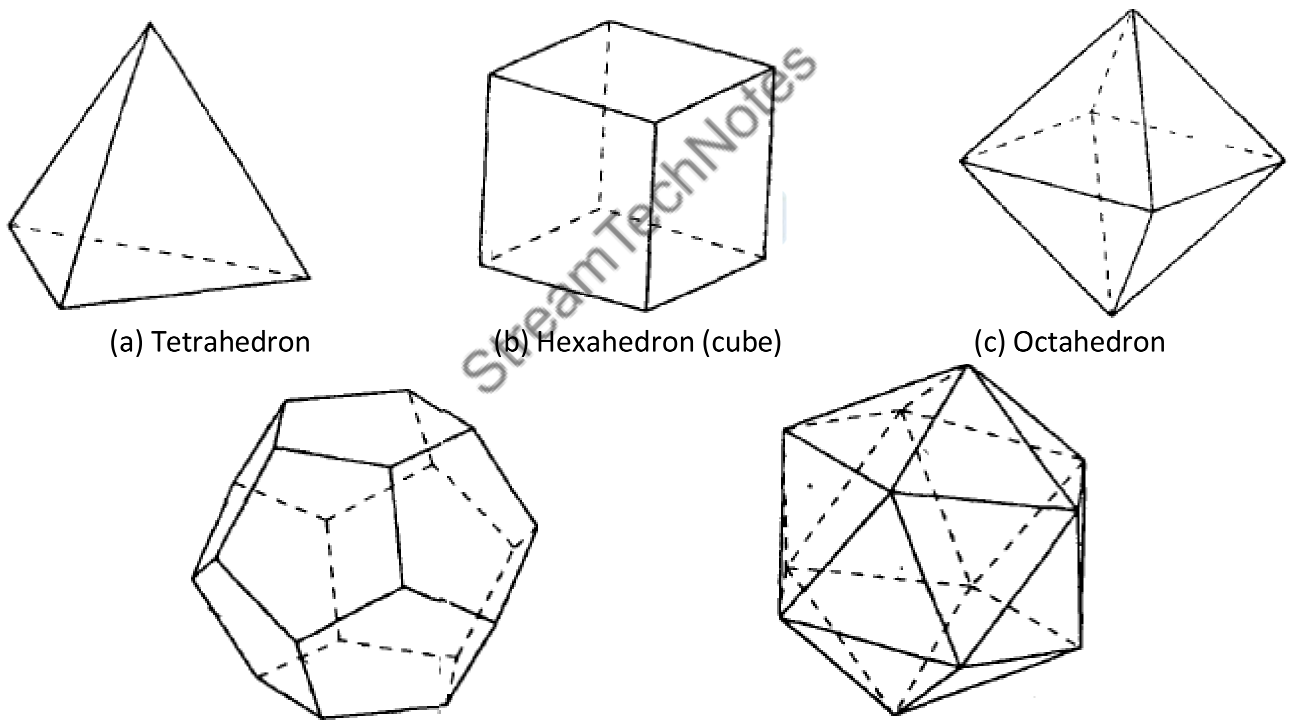
1. Polyhedra

Polyhedra are defined as a solid bounded by plane surfaces called faces. They are:

(i) Regular polyhedra
(ii) Prisms and
(iii) Pyramids

(i) Regular Polyhedra

A polyhedron is said to be regular if its surfaces are regular polygons. The following are some of the regular polyhedra.



(a) Tetrahedron (b) Hexahedron (cube) (c) Octahedron

(d) Dodecahedron (d) Icosahedron

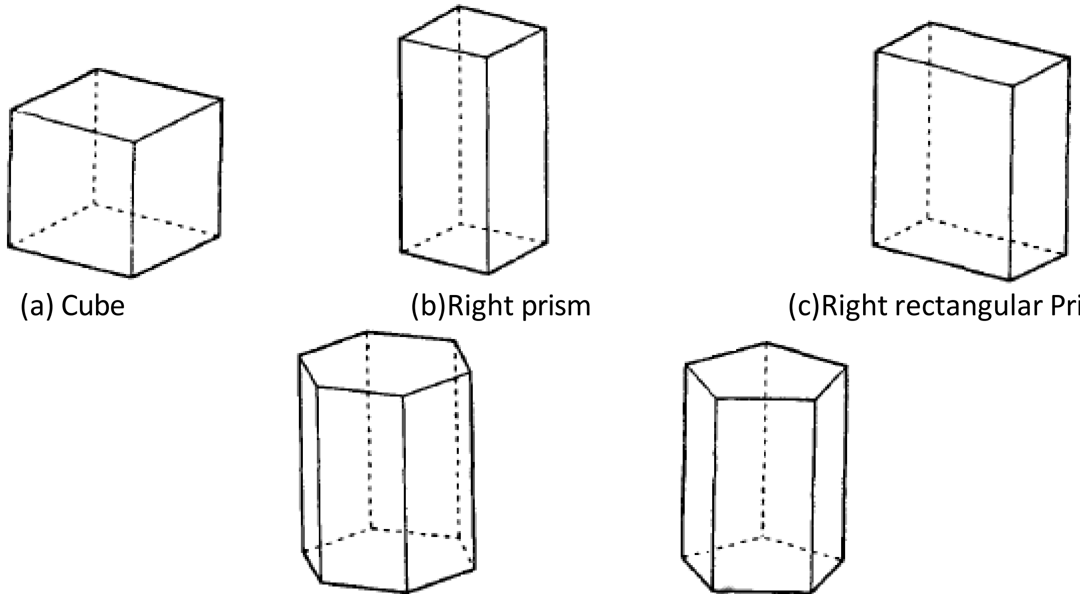
Fig. 3.1

(a) Tetrahedron: It consists of four equal faces, each one being a equilateral triangle.
(b) Hexahedron (cube): It consists of six equal faces, each a square.
(c) Octahedron: It has eight equal faces, each an equilateral triangle.
(d) Dodecahedron: It has twelve regular and equal pentagonal faces.
(e) Icosahedron: It has twenty equal, equilateral triangular faces.

(ii) Prisms

A prism is a polyhedron having two equal ends called the bases parallel to each other. The two bases are joined by faces, which are rectangular in shape. The imaginary line passing through the centers of the bases is called the axis of the prism.

A prism is named after the shape of its base. For example, a prism with square base is called a square prism, the one with a pentagonal base is called a pentagonal prism, and and so on (Fig. 3.2) The nomenclature of the prism is given in Fig. 3.3.



(a) Cube (b)Right prism (c)Right rectangular Prism

(d) Right pentagonal prism (e) Hexagonal prism

Fig. 3.2

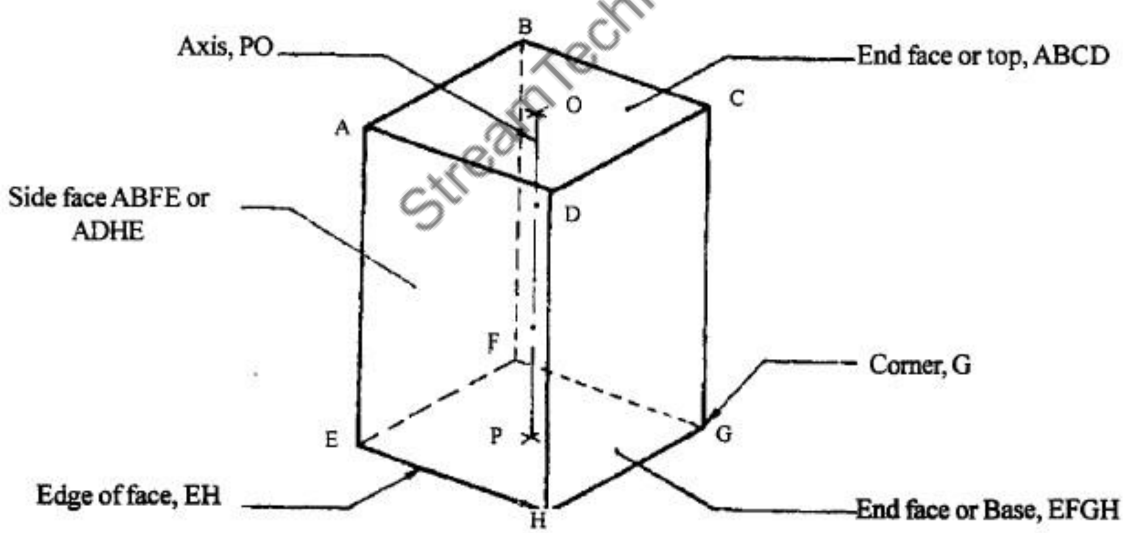
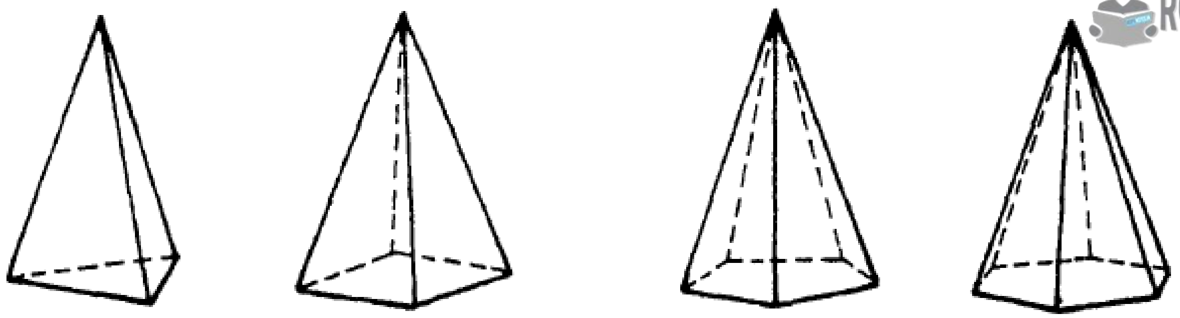


Fig. 3.3 Nomenclature of a Square Prism

(iii) Pyramids

A pyramid is a polyhedron having one base, with a number of isosceles triangular faces, meeting at a point called the apex. The imaginary line passing through the centre of the base and the apex is called the axis of the pyramid.

The pyramid is named after the shape of the base. Thus, a square pyramid has a square base and pentagonal pyramid has pentagonal base and so on (Fig. 3.4). The nomenclature of a pyramid is shown in Fig. 3.5.



(a) Triangular (b) Square (c) Pentagonal (d) Hexagonal

Fig. 3.4

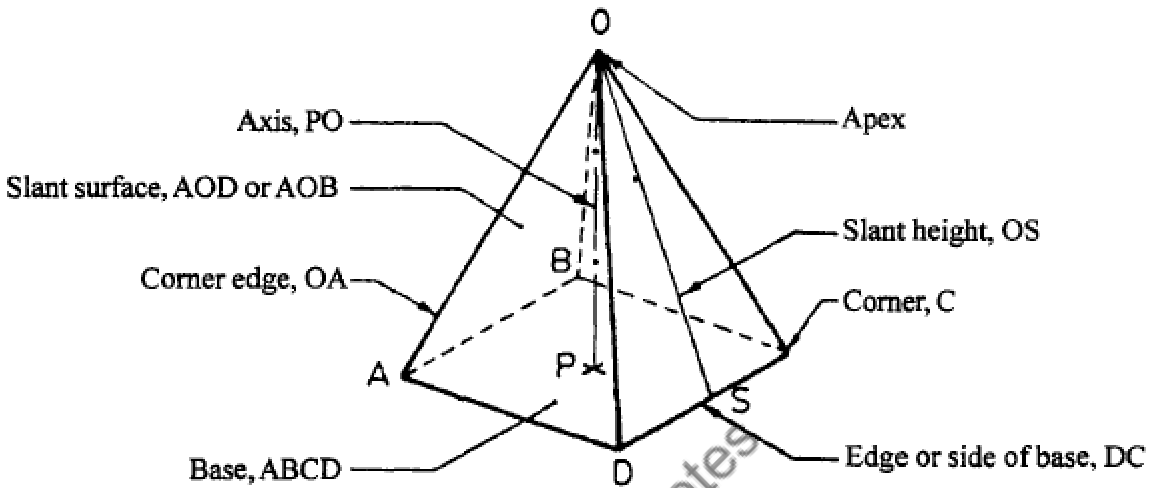


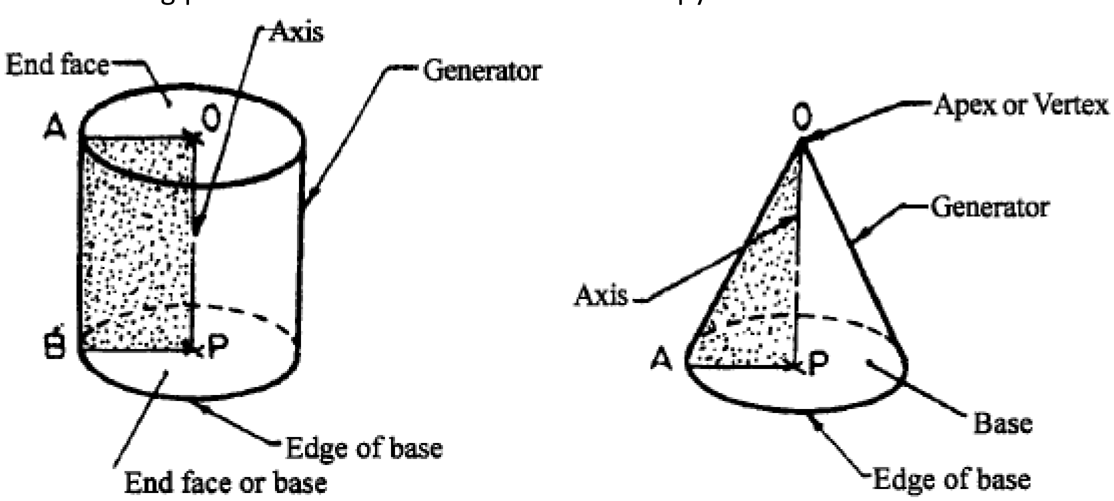
Fig. 3.5 Nomenclature of a Square Pyramid

2. Solids of Revolution

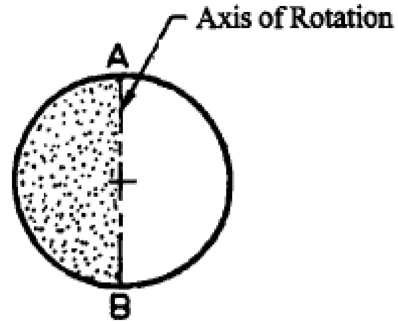
If a plane surface is revolved about one of its edges, the solid generated is called a solid of revolution. The examples are (i) Cylinder, (ii) Cone, (iii) Sphere

Frustums and Truncated Solids

If a cone or pyramid is cut by a section plane parallel to its base and the portion containing the apex or vertex is removed, the remaining portion is called frustum of a cone or pyramid



(a) Cylinder (b) Cone



(c) Sphere

Fig. 3.6 Solid of Revolution

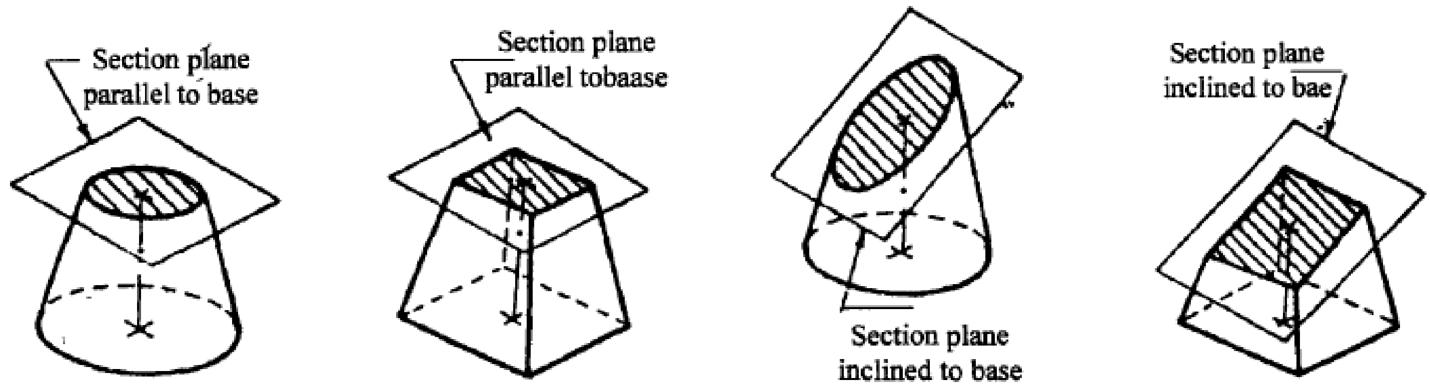


Fig. 3.7 Frustum of a Solid and Truncated Solids

Prisms (problem) Position of a Solid with Respect to the Reference Planes

The position of solid in space may be specified by the location of the axis, base, edge, diagonal or face with the principal planes of projection. The following are the positions of a solid considered.

1. Axis perpendicular to one of the principal planes.
2. Axis parallel to both the principal planes.
3. Axis inclined to one of the principal planes and parallel to the other.
4. Axis inclined to both the principal planes.

The position of solid with reference to the principal planes may also be grouped as follows:

1. Solid resting on its base.
2. Solid resting on anyone of its faces, edges of faces, edges of base, generators, slant edges, etc.
3. Solid suspended freely from one of its comers, etc.

1. Axis perpendicular to one of the principal planes

A) Axis perpendicular to H. P.

When the axis of a solid is perpendicular to one of the planes, it is parallel to the other. Also, the projection of the solid on that plane will show the true shape of the base.

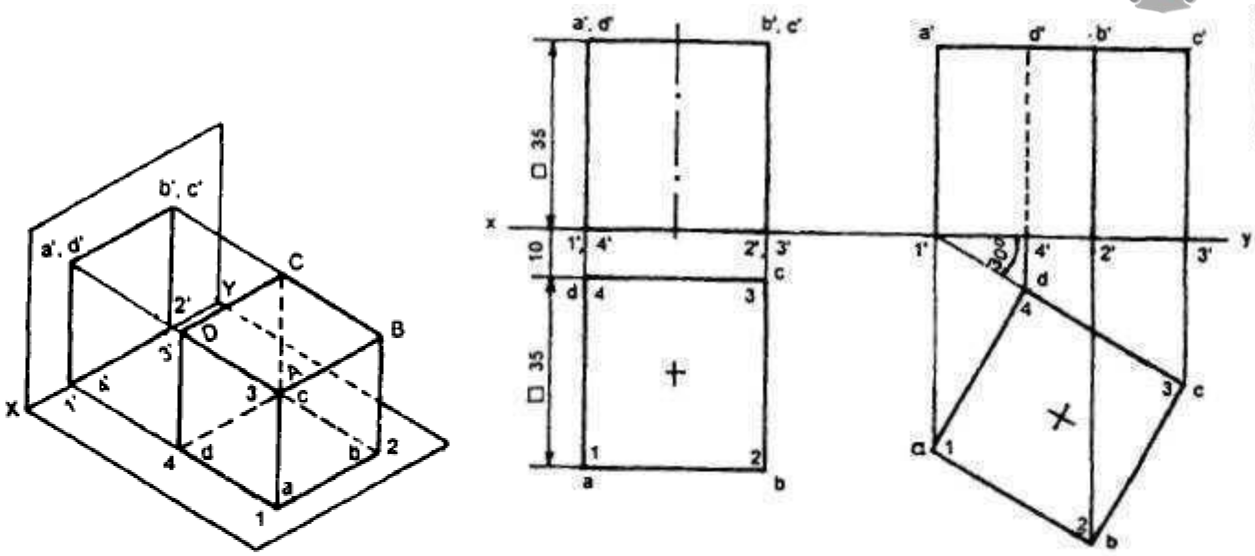
When the axis of a solid is perpendicular to H.P, the top view must be drawn first and then the front view is projected from it. Similarly when the axis of the solid is perpendicular to V.P, the front view must be drawn first and then the top view is projected from it.

Problem: Draw the projections of a cube of 35 mm side, resting on one of its faces (bases) on H.P., such that one of its vertical faces is parallel to and 10 mm in front of V.P.

Construction: Above figure shows the cube positioned in the first quadrant.

1. Draw the top view such that one of its edges is 10mm below XY.
2. Obtain the front view by projection, keeping one of its bases on XY.

Note: (i) For the cube considered ABCD is the top base and 1234 the bottom base, (ii) Fig. 3.8 c shows the projections of a cube, resting on one of its bases on H.P. such that an edge of its base is inclined at 30° to V.P.



(a) (b) (c)

Fig. 3.8

B) Axis perpendicular to V. P.

Problem: A square prism with side of base 35 mm and axis 50 mm long, lies with one of its longest edges on H.P such that its axis is perpendicular to V.P. Draw the projections of the prism when one of its rectangular faces containing the above longer edge is inclined at 30° to H.P.,

Construction:

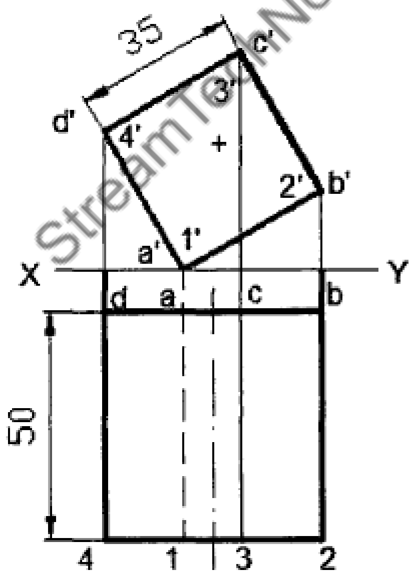


Fig. 3.9

1. Draw the front view which is a square of 35mm such that one of its corners is on XY and a side passing through it is making 30° with XY.

2. Obtain top view by projection, keeping the length as 50mm.

Note: The distance of the base nearer to V.P is not given in the problem. Hence, the top view may be drawn keeping the base nearer to XY at any convenient distance.

2. Axis parallel to both the principal planes

When the axis of solid is parallel to both the planes, neither the front view nor the top view reveal the true shape of the base. In such case, the side view must be drawn first which shows the true shape of the base. The front and top view are then projected from the side view.

Problem: Hexagonal prism with side of base 25 mm and axis 60 mm long is lying on one of its rectangular faces on HP. Draw the projections of the prism when its axis is parallel to both HP and V.P.

Construction:

1. Draw the right side view of the hexagon, keeping an edge on XY.
2. Draw the second reference line X_1Y_1 perpendicular to XY and to the right of the above view at any convenient location.
3. Obtain the front view by projection, keeping its length equal to 60 mm.
4. Obtain the top view by projecting the above views.

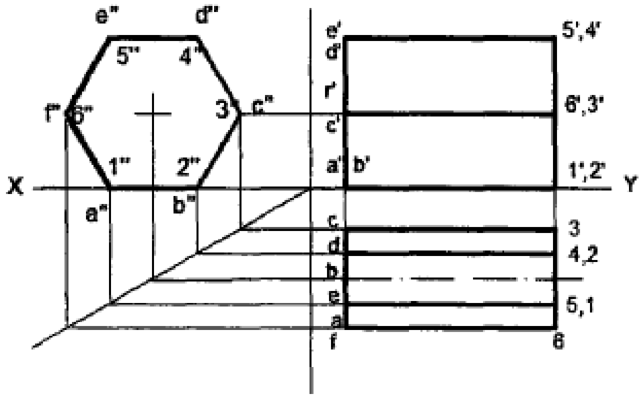


Fig. 3.10

3. Axis inclined to one of the principal planes and parallel to the other:

A) Axis inclined to H.P. and parallel to V.P.

When the axis of a solid is inclined to any plane, the projections are obtained in two stages. In the first stage, the axis of the solid is assumed to be perpendicular to the plane to which it is actually inclined and the projections are drawn. In second stage, the position of one of the projections is altered to satisfy the given condition and the other view is projected from it. This method of obtaining the projections is known as the change of position method.

Problem: A pentagonal prism with side of base 30 mm and axis 60 mm long is resting with an edge of its base on HP, such that the rectangular face containing that edge is inclined at 60° to HP. Draw the projections of the prism when its axis is parallel to V.P.

Construction:

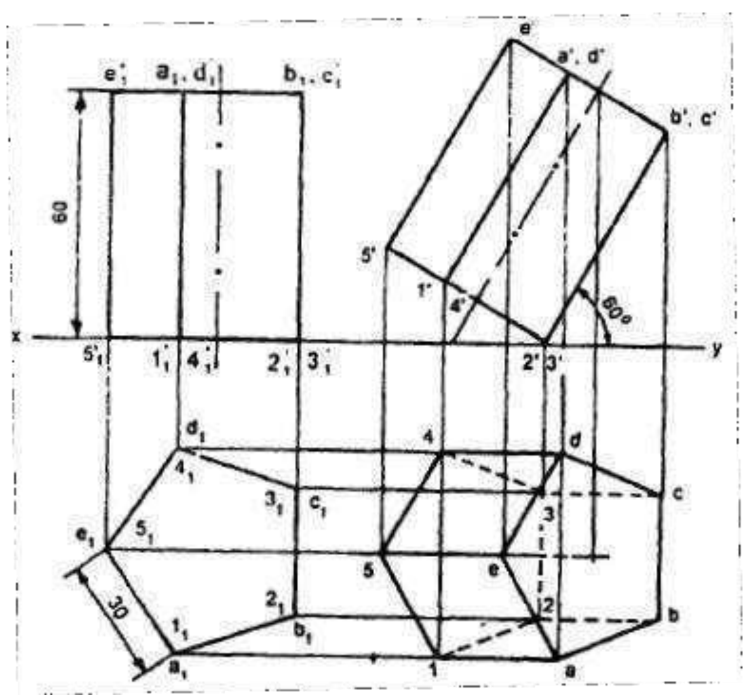


Fig. 3.11

Stage 1

Assume that the axis is perpendicular to H.P.

1. Draw the projections of the prism keeping an edge of its base perpendicular to V.P.

Stage 2

1. Rotate the front view so that the face containing the above edge makes the given angle with the H.P.
2. Redraw the front view such that the face containing the above edge makes 60° with XY. This is the final front view.
3. Obtain the final top view by projection.

Note: For completing the final projections of the solids inclined to one or both the principal planes, the following rules and sequence may be observed.

(i) Draw the edges of the visible base. The base is further away from XY in one view will be fully visible in the other view.

(ii) Draw the lines corresponding to the longer edges of the solid, keeping in mind that the lines passing through the visible base are invisible.

(iii) Draw the edges of the other base.

B) Axis inclined to V.P. and parallel to H.P.

Problem: A pentagonal prism with side of base 25 mm and axis 50 mm long lies on one of its faces on H.P., such that its axis is inclined at 45° to V.P. Draw the projections.

Construction:

1. Assuming that the axis is perpendicular to V.P, draw the projections keeping one side of the pentagon coinciding with XY.
2. Redraw the top view so that the axis is inclined at 45° to XY. This is the final top view.
3. Obtain the final front view by projection.

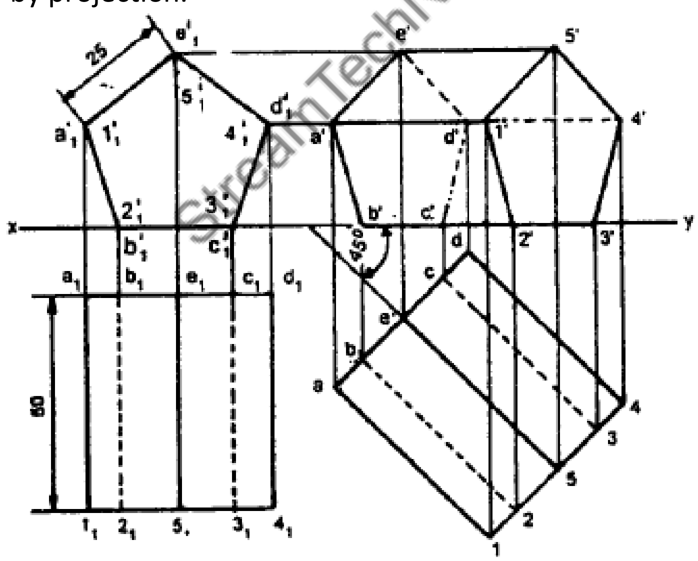


Fig. 3.12

4. Axis inclined to both the principal planes

A solid is said to be inclined to both the planes when (i) the axis is inclined to both the planes, (ii) the axis is inclined to one plane and an edge of the base is inclined to the other. In this case the projections are obtained in three stages.

Stage I

Assume that the axis is perpendicular to one of the planes and draw the projections.

Stage II

Rotate one of the projections till the axis is inclined at the given angle and project the other view from it.

State III

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

Problem: A square prism with side of base 30 mm and axis 50 mm long has its axis inclined at 60° to H.P., on one of the edges of the base which is inclined at 45° to V.P.

Construction:

1. Draw the projections of the prism assuming it to be resting on one of its bases on H.P. with an edge of it perpendicular to V.P.
2. Redraw the front view such that the axis makes 60° with XY and project the top view from it.
3. Redraw the top view such that the edge on which the prism is resting on H.P is inclined at 45° to XY. This is the final top view.
4. Obtain the final front view by projection.

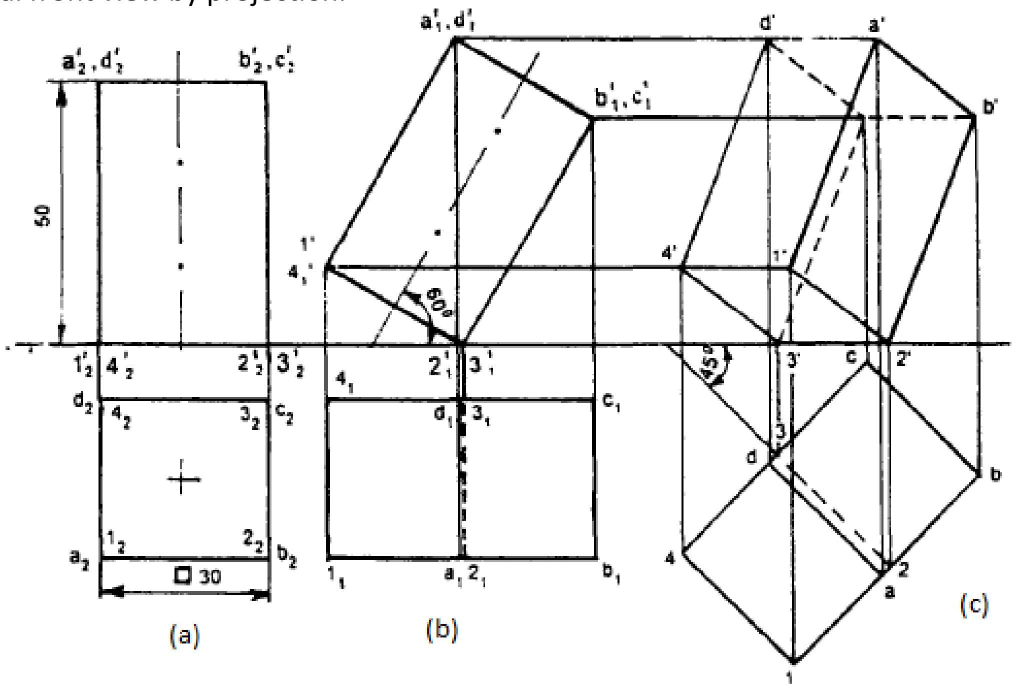


Fig. 3.13

Pyramids

1. Axis perpendicular to one of the principal planes

A) Axis perpendicular to H. P.

Problem: A square pyramid with side of base 30 mm and axis 50 mm long is resting with its base on HP. Draw the projections of the pyramid when one of its base edges is parallel to V.P. The axis of the pyramid is 30 mm in front of V.P.

Construction:

1. Draw the top view, a square, keeping its centre at 30mm from XY and with an edge parallel to XY.
2. Obtain the front view by projection keeping the height equal to 5O mm and the base lying on XY.

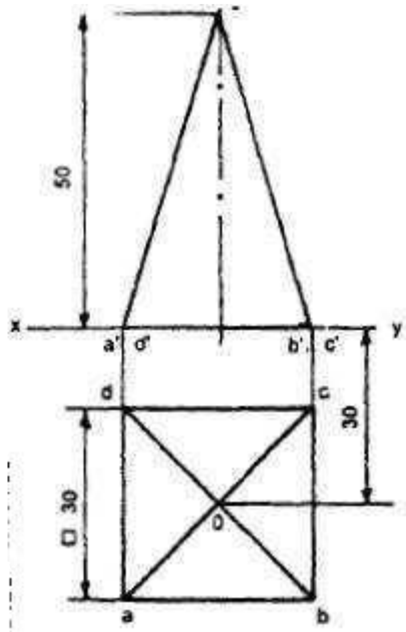


Fig. 3.14

B) Axis perpendicular to V. P.

Problem: Draw the projections of a pentagonal pyramid of side of base 30mm and axis 50mm long when its axis is perpendicular to V.P. and an edge of its base is perpendicular to H.P

Construction:

1. Draw the front view of the pyramid which is a pentagon, keeping one of its side perpendiculars to XY.
2. Obtain the top view by projection keeping the axis length equal to 50 mm.

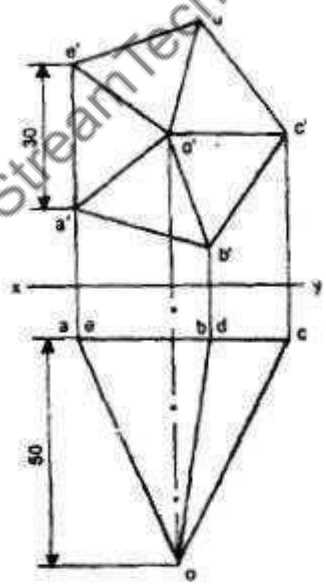


Fig. 3.15

2. Axis parallel to both the principal planes

Problem: A pentagonal pyramid with side of base 30 mm and axis 60 mm long rests with an edge of its base on HP such that its axis is parallel to both HP and V.P. Draw the projection of the solid.

Construction:

1. Draw the projections of the pyramid with its base on H.P and an edge of the base (BC) perpendicular to V.P.
2. Redraw the front view such that b(c) lies on XY and the axis is parallel to XY which is the final front view.
3. Obtain the final top view by projection.

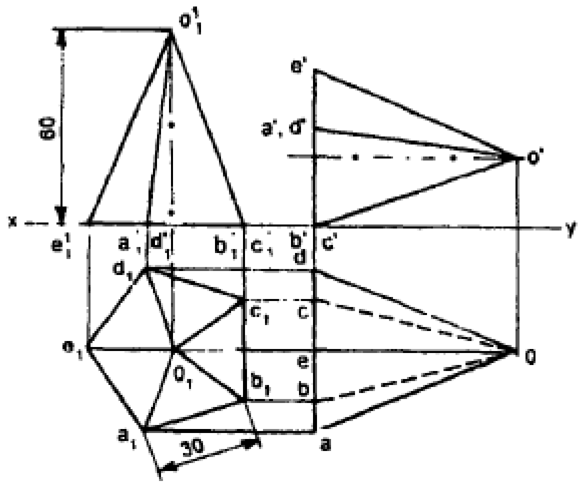


Fig. 3.16

3. Axis inclined to one of the principal planes and parallel to the other:

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

Construction:

1. Assuming the axis is perpendicular to H.P draw the projections keeping one edge of the base perpendicular to V.P.
2. Redraw the front view so that the line o^{l}-c (d) representing the slant face, coincides with XY. This is the final front view.
3. Obtain the final top view by projection.

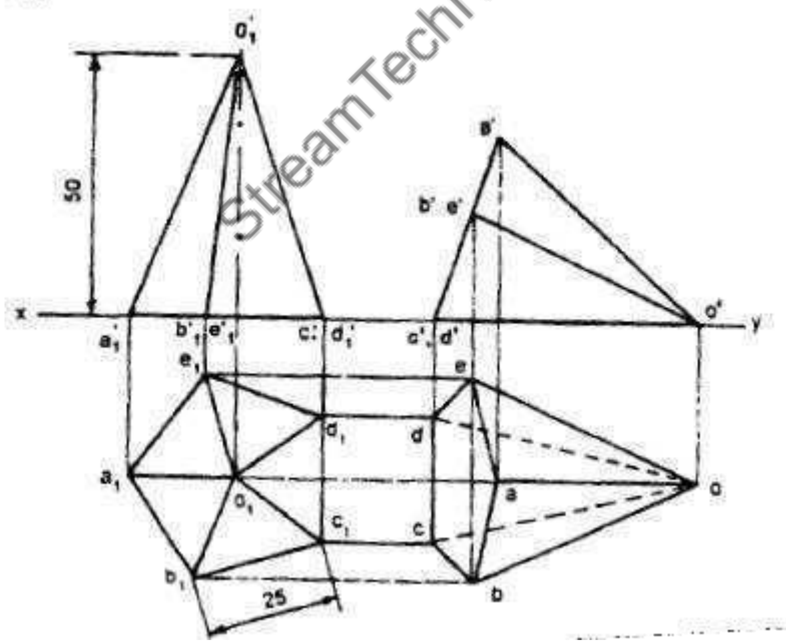


Fig. 3.17

Cone and cylinder

Problem: Draw the projection of a cone of base 40 mm diameter, axis 60 mm long when it is resting with its base on H.P.

Construction:

1. Draw the reference line XY and locate 0 at a convenient distance below it.
2. With centre O and radius 20 mm draw a circle forming the top view.
3. Obtain the front view by projection, keeping the height equal to 60 mm and the base coinciding with XY.

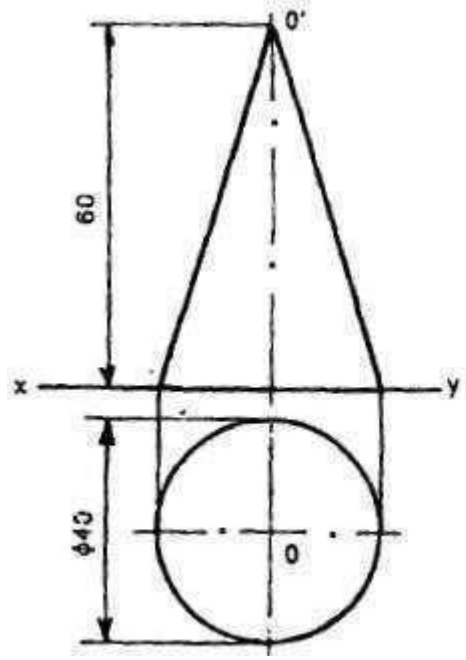


Fig. 3.18

Problem: A cone with base 30 mm diameter and axis 45 mm long lies on a point of its base on V.P. such that the axis makes an angle 45° with V.P. Draw the projections of the cone.

Construction:

1. Draw the projections of the cone assuming that the cone is resting with its base on V.P.
2. Divide the circle into a number of equal parts and draw the corresponding generators in the top view.
3. Redraw the top view so that the axis makes 45° with XY. This is the final top view.
4. Obtain the final view by projection.

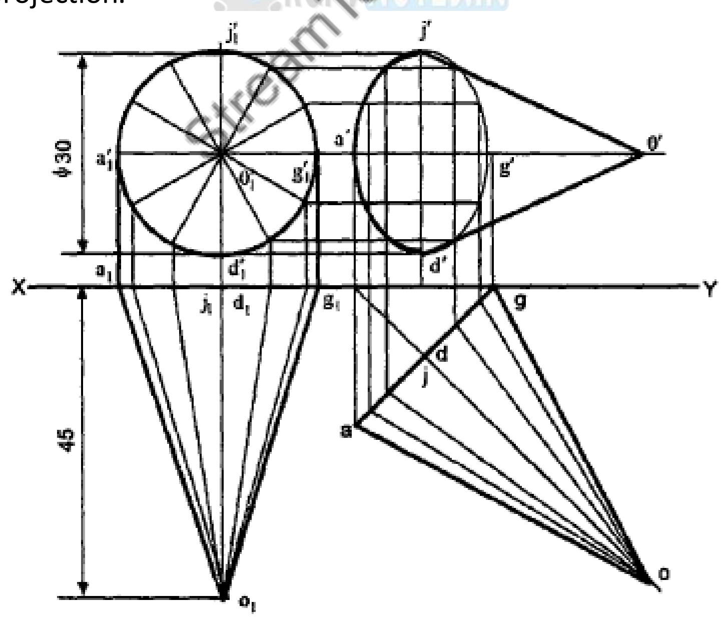


Fig. 3.19

Problem: A cylinder with base 40 mm diameter and 50 mm long rests on a point of its base on HP such that the axis makes an angle of 30° with HP. Draw the projections of the cylinder.

Construction:

1. Draw the projection of the cylinder assuming that the cylinder is resting with its base on H.P.
2. Divide the circle into a number of equal parts and obtain the corresponding generators in the front view.
3. Redraw the front view such that its axis makes 30° with XY. This is the final front view.
4. Obtain the final top view by projection.

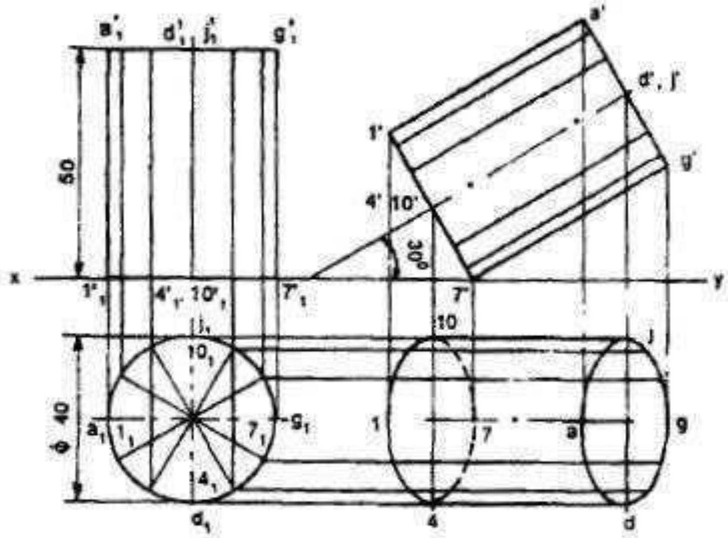


Fig. 3.20

Module - IV

Sections and Sectional Views of Right Angular Solids covering, Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only)

Sections of Solids:

Introduction

Sections and sectional views are used to show hidden detail more clearly. They-are created by using a cutting plane to cut the object.

A section is a view of no thickness and shows the outline of the object at the cutting plane. Visible outlines beyond the cutting plane are not drawn.

A sectional view, displays the outline of the cutting plane and all visible outlines which can be seen beyond the cutting plane.

Improve visualization of interior features. Section views are used when important hidden details are in the interior of an object. These details appear as hidden lines in one of the orthographic principal views; therefore, their shapes are not very well described by pure orthographic projection.

Types of Section Views

- Full sections
- Half sections
- Offset sections
- Revolved sections
- Removed sections
- Broken-out sections

Cutting Plane

- Section views show how an object would look if a cutting plane (or saw) cut through the object and the material in front of the cutting plane was discarded

Representation of cutting plane

According to drawing standards cutting plane is represented by chain line with alternate long dash and dot. The two ends of the line should be thick.

Full Section View

- In a full section view, the cutting plane cuts across the entire object
- Note that hidden lines become visible in a section view

Hatching

On sections and sectional views solid area should be hatched to indicate this fact. Hatching is drawn with a thin continuous line, equally spaced (preferably about 4 mm apart, though never less than 1 mm) and preferably at an angle of 45°.

(i) Hatching a single object: When you are hatching an object, but the objects have areas that are separated. All areas of the object should be hatched in the same direction and with the same spacing.

(ii) Hatching Adjacent objects: When hatching assembled parts, the direction of the hatching should ideally be reversed on adjacent parts. If more than two parts are adjacent, then the hatching should be staggered to emphasize the fact that these parts are separate.

Problem: A square prism of base side on 30 mm and axis length 60 mm is resting on HP on one of its bases, with a base side inclined at 30° to VP. It is cut by a plane inclined at, 4O° to. HP and perpendicular to VP and is bisecting the axis of the prism. Draw its front view, sectional top view and true shape of section.

Solution: Draw the projections of the prism in the given position. The top view is drawn and the front view is projected.

To draw the cutting plane, front view and sectional top view

1. Draw the Vertical Trace (VT) of the cutting plane inclined at 40° to XY line and passing through the midpoint of the axis.
2. As a result of cutting, longer edge a' p' is cut, the end a' has been removed and the new comer I' is obtained.
3. Similarly 2' is obtained on longer edge b' q', 3' on c' r' and 4' on d's',
4. Show the remaining portion in front view by drawing dark lines.
5. Project the new points 1', 2', 3' and 4' to get 1, 2, 3 and 4 in the top view of the prism, which are coinciding with the bottom end of the longer edges p, q, r and s respectively.
6. Show the sectional top view or apparent section by joining 1, 2, 3 and 4 by drawing hatching lines.

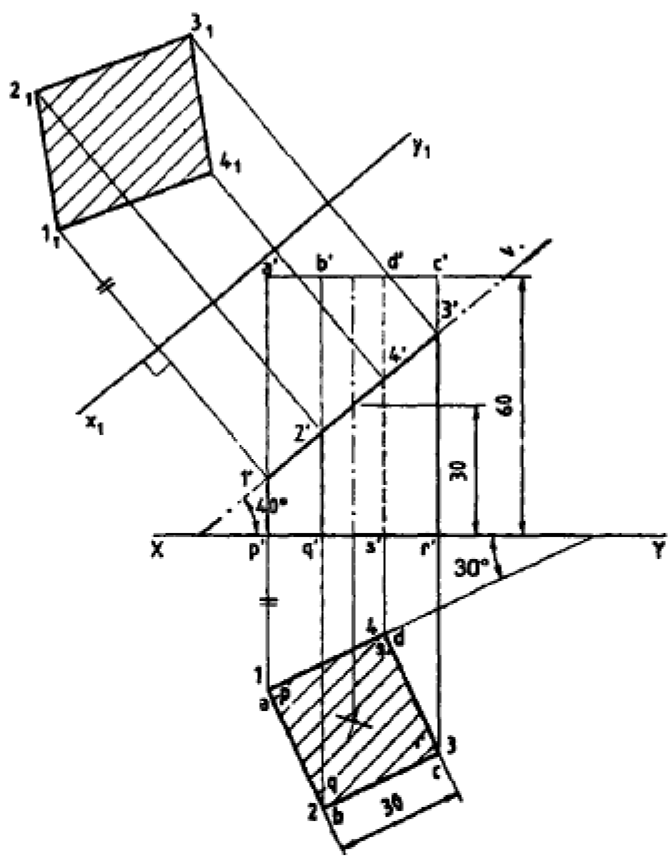


Fig. 4.1

To draw the' true shape of a section

1. Consider an auxiliary inclined plane parallel to the cutting plane and draw the new reference line X_lY_l parallel to VT of the cutting plane at an arbitrary distance from it.
2. Draw projectors passing through 1', 2', 3' and 4' perpendicular to X_l Y_l line.
3. The distance of point 1 in top view from XY line is measured and marked from X_l Y_l in the projector passing through 1^l to get $1_1{}^l$. This is repeated to get the other points 2_1, 3_1 and 4_1.
4. Join these points to get the true shape of section as shown by drawing the hatching lines.

Development of surfaces of various solids:

Introduction

A layout of the complete surface of a three dimensional 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.

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 following 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.

Development of Prism

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

Construction:

1. Assume the prism is resting on its base on H.P. with an edge of the base parallel 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 succession i.e. 1-2, 2-3, 3-4 and 4-1.
3. Erect perpendiculars through 1, 2, 3 etc., and mark the edges (folding lines) I-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 an)' of the base edges.

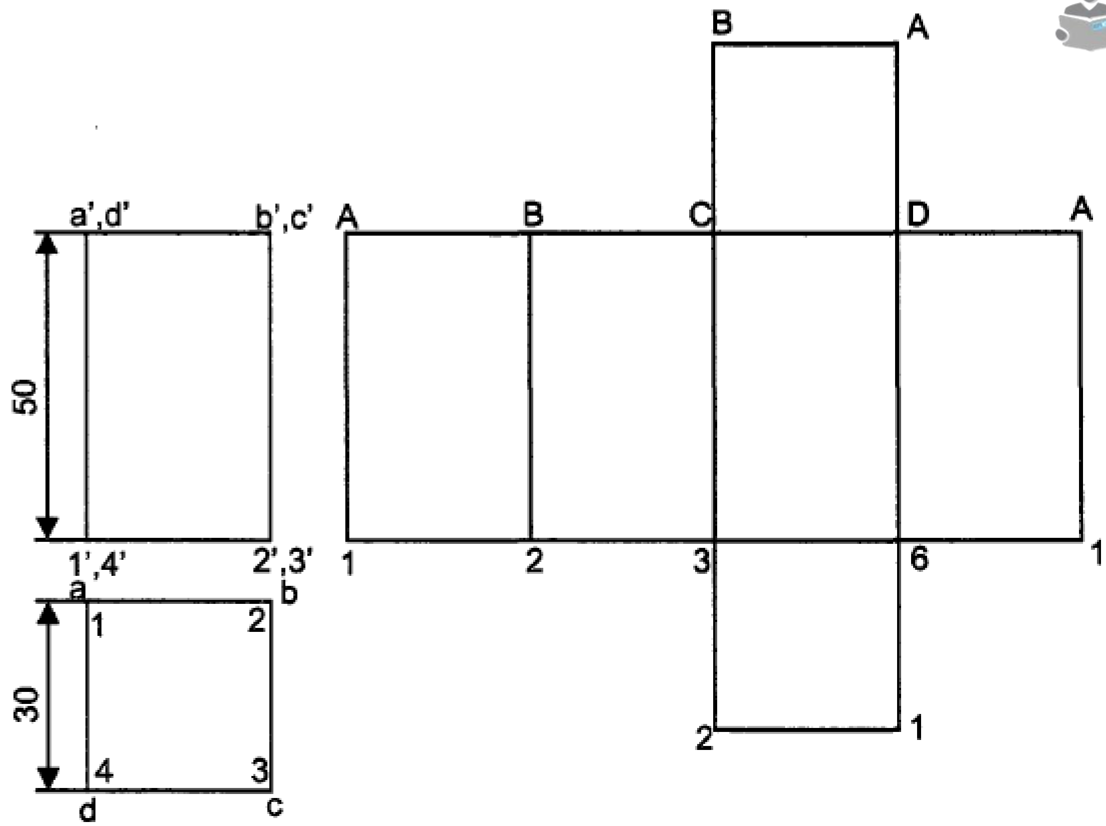


Fig. 4.2 Development of Prism

Development of a Cylinder

Construction:

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

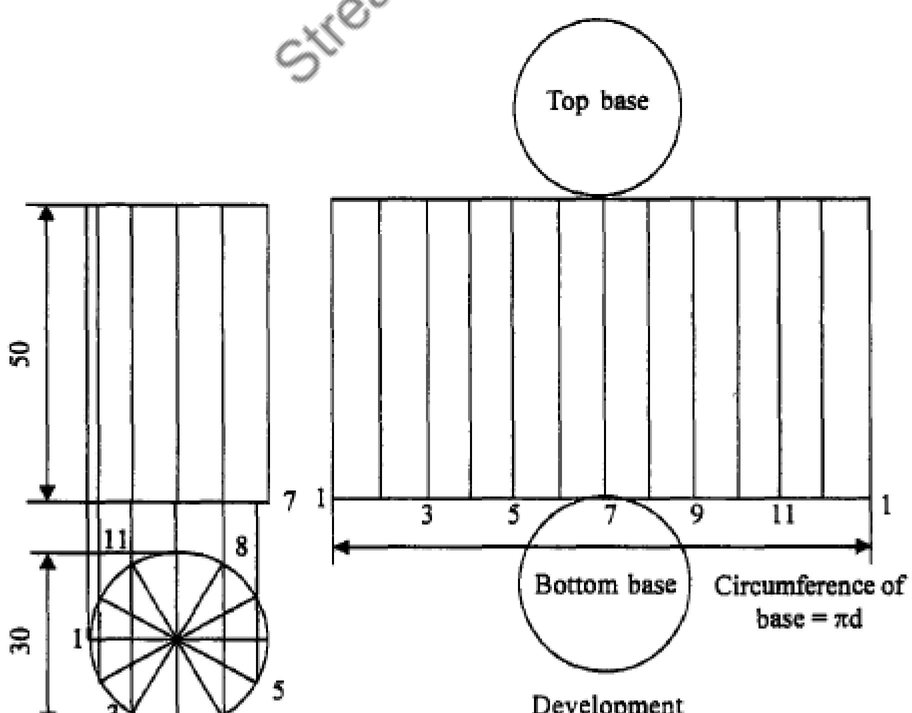


Fig. 4.3 Development of Cylinder

Development of a Pyramid

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

Construction:

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 oa 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 length of the slant edge, say OA, rotate oa till it is parallel to XY to the position oa_1. Through a_1, draw a projector to meet the line XY at a_1'. Then $o_1'a_1'$ all 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 0 and radius $o'a'$ draw an arc.
4. Starting from A along the arc, mark the edges of the base i.e. AB, BC, CD and DA.
5. Join 0 to A, B, C, etc., representing the lines of folding and thus completing the development.

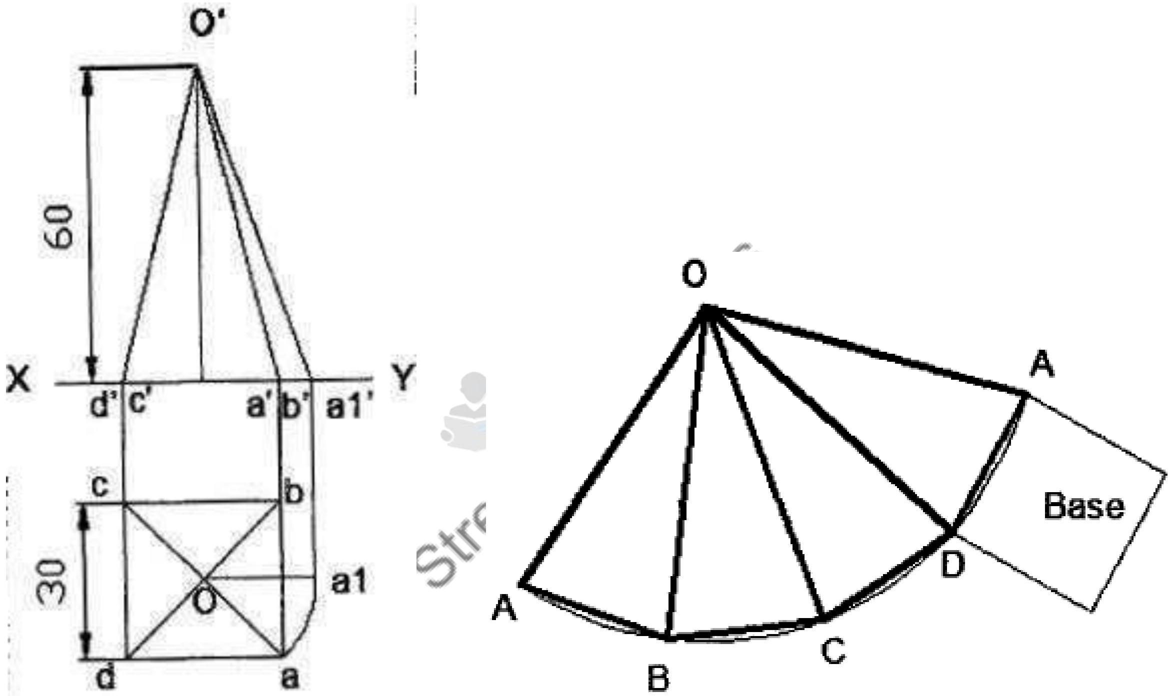


Fig. 4.4 Development of Square Pyramid

Development of Pentagonal Pyramid

Construction:

1. Draw the orthographic views of the pyramid ABCDE with its base on H.P and axis parallel to V.P.
2. With centre 0 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 0 representing the lines of folding.
4. Add the base at a suitable location.

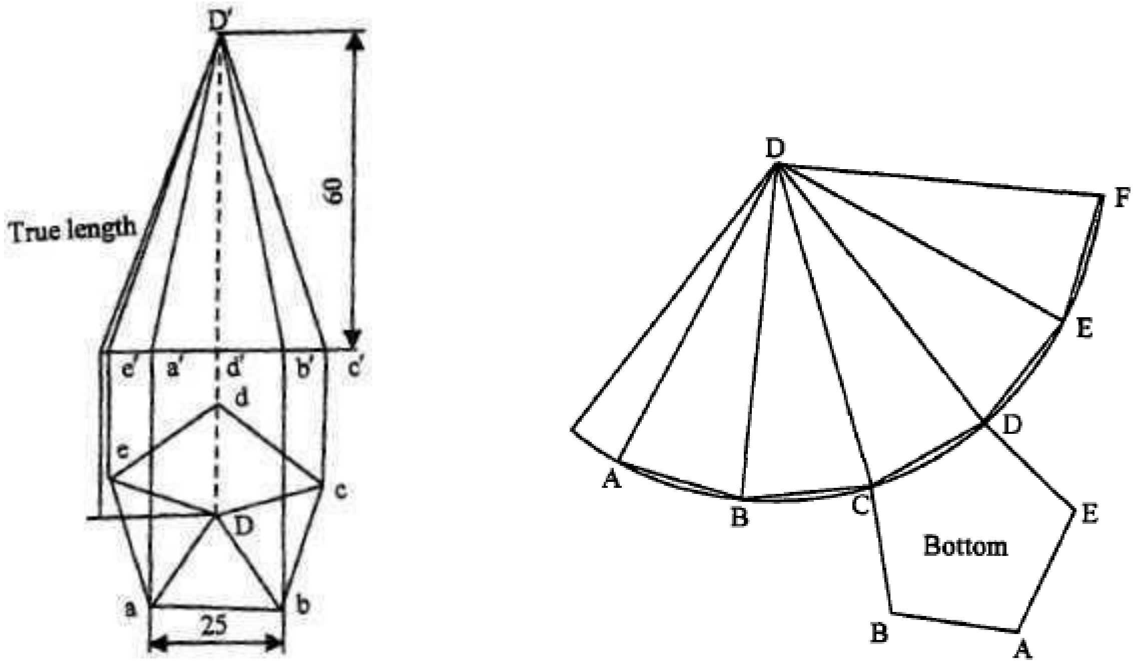


Fig. 4.5 Development of Pentagonal Pyramid

Development of a Cone
Construction:

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) x 360°, where r is the radius of the base of the cone and s is the true length.

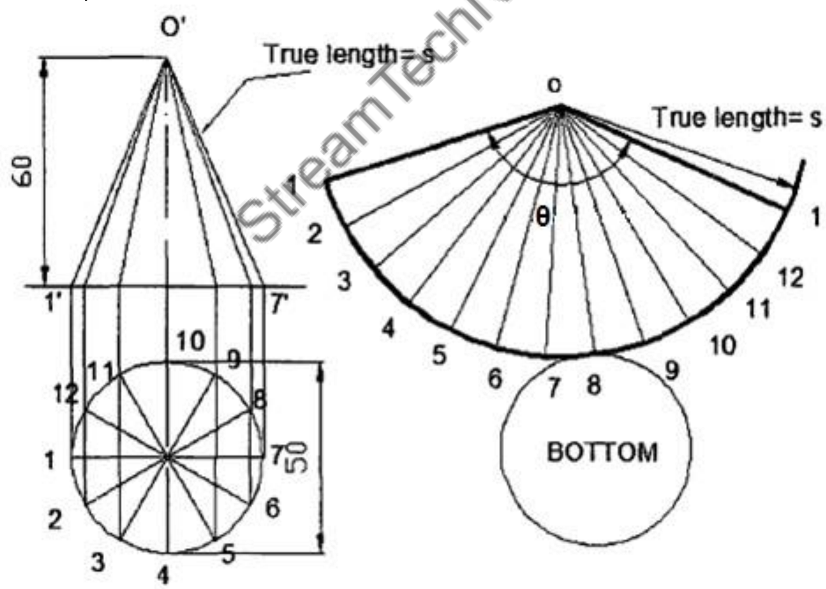


Fig. 4.6 Development of Cone

$\theta = (r \times s) \times 360°$

Where, r = Radius of base of Cone

s = Slant Height

Module V

Isometric Projections covering, Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids

Orthographic Projections:

Introduction

Any object has three dimensions, viz., length, width and thickness. A projection is defined as a representation of an object on a two dimensional plane. The projections of an object should convey all the three dimensions, along with other details of the object on a sheet of paper. The elements to be considered while obtaining a projection are:

(i) The object

(ii) The plane of projection

(iii) The point of sight

(iv) The rays of sight

A projection may be obtained by viewing the object from the point of sight and tracing in correct sequence, the points of intersection between the rays of sight and the plane on to which the object is projected. A projection is called orthographic projection when the point of sight is imagined to be located at infinity so that the rays of sight are parallel to each other and intersect the plane of projection at right angle to it.

The principles of orthographic projection may be followed in four different angles or systems, viz., first, second, third and fourth angle projections. A projection is said to be first, second, third or fourth angle when the object is imagined to be in the first, second, third or fourth quadrant respectively. However, the Bureau of Indian Standards (SP–46:1988) prefers first angle projection and throughout this book, first angle projection is followed.

Principle of First Angle Projection

In first angle projection, the object is imagined to be positioned in the first quadrant. The view from the front of the object is obtained by looking at the object from the right side of the quadrant and tracing in correct sequence, the points of intersection between the projection plane and the rays of sight extended. The object is between the observer and the plane of projection (vertical plane). Here, the object is imagined to be transparent and the projection lines are extended from various points of the object to intersect the projection plane. Hence, in first angle projection, any view is so placed that it represents the side of the object away from it.

Methods of obtaining Orthographic Views

1. View from Front

The view from the front of an object is defined as the view that is obtained as projection on the vertical plane by looking at the object normal to its front surface. It is the usual practice to position the object such that its view from the front reveals most of the important features. Figure shows the method of obtaining the view from the front of an object.

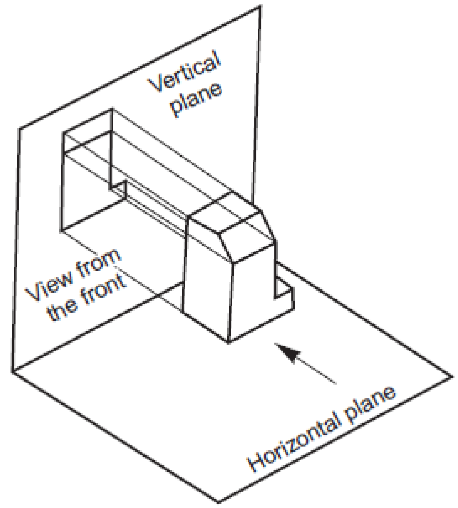


Fig. 5.1 Principle of obtaining the view from the front

2. View from above

The view from above of an object is defined as the view that is obtained as projection on the horizontal plane, by looking the object normal to its top surface. Figure shows the method of obtaining the view from above of an object.

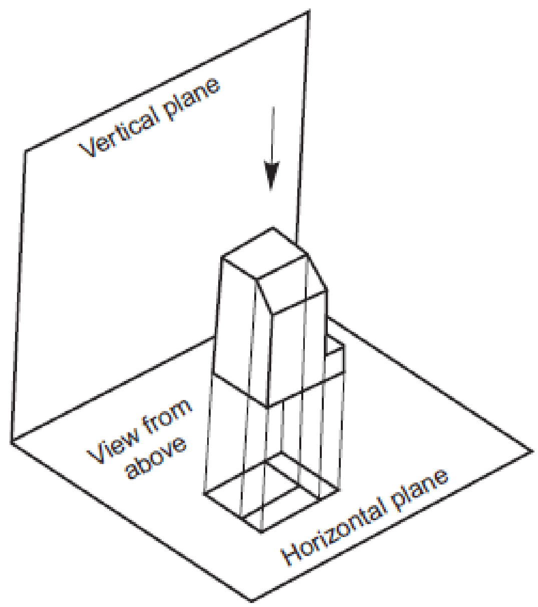


Fig. 5.2 Principle of obtaining the view from the above

3. View from the Side

The view from the side of an object is defined as the view that is obtained as projection on the profile plane by looking the object, normal to its side surface. As there are two sides for an object, viz., left side and right side, two possible views from the side, viz., view from the left and view from the right may be obtained for any object. Figure shows the method of obtaining the view from the left of an object.

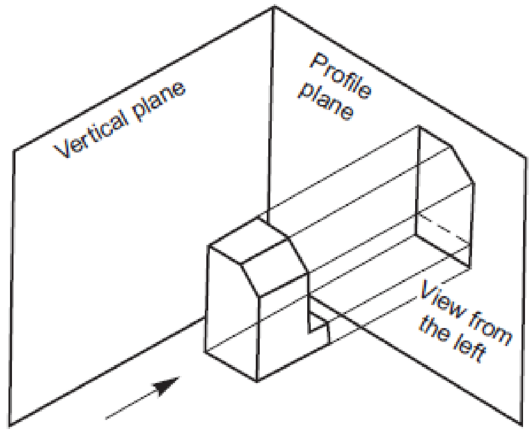


Fig. 5.3 Principle of obtaining the view from the Left

Presentation of Views

The different views of an object are placed on a drawing sheet which is a two dimensional one, to reveal all the three dimensions of the object. For this, the horizontal and profile planes are rotated till they coincide with the vertical plane. Figure shows the relative positions of the views, viz., the view from the front, above and the left of an object.

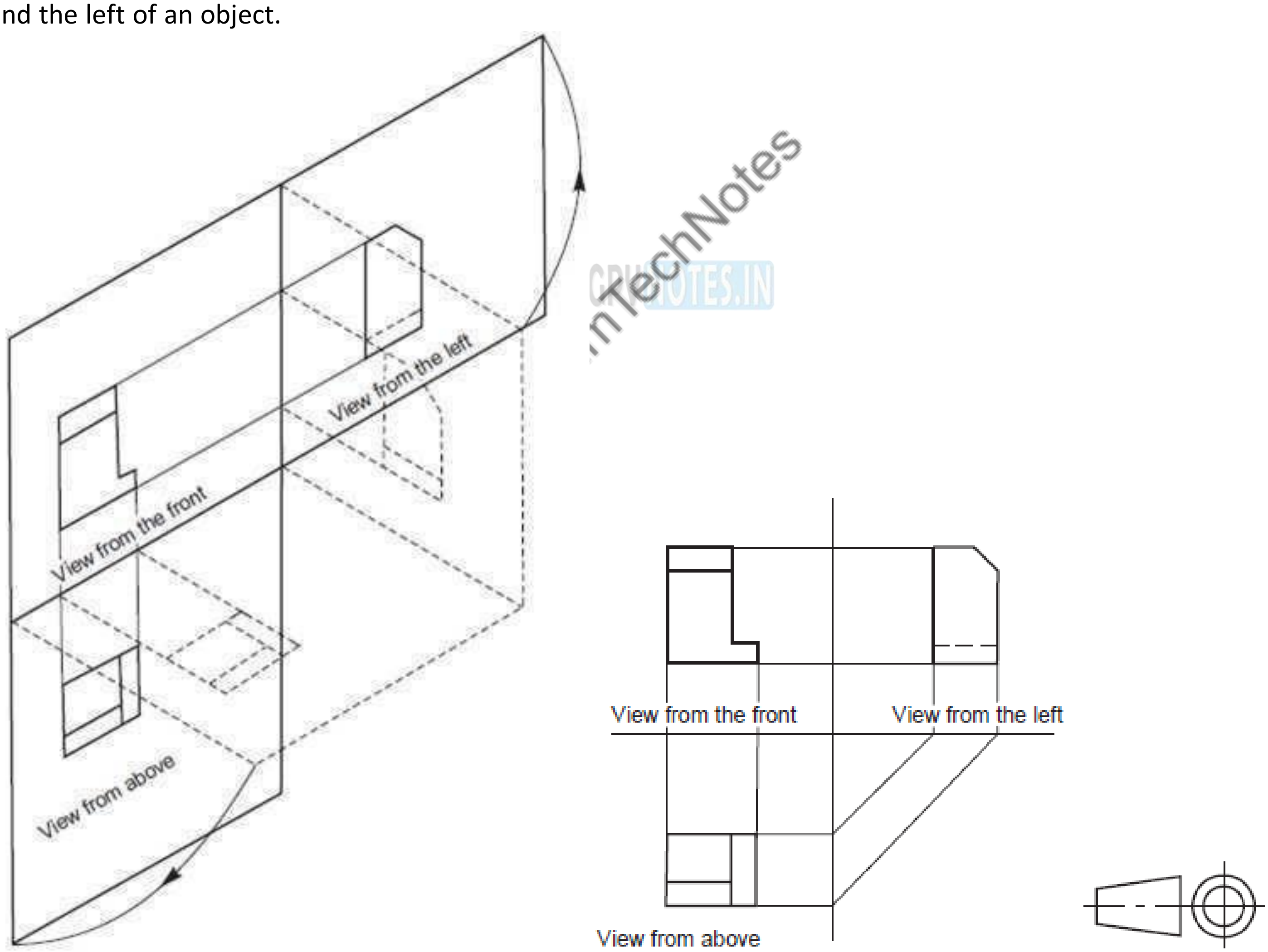


Fig. 5.5 Relative positions of the three views and the symbol

Designation and Relative Positions of Views

An object positioned in space may be imagined as surrounded by six mutually perpendicular planes. So, for any object, six different views may be obtained by viewing at it along the six directions, normal to these planes. Figure shows an object with six possible directions to obtain the different views which are designated as follows:

1. View in the direction **a** = view from the front
2. View in the direction **b** = view from above
3. View in the direction **c** = view from the left
4. View in the direction **d** = view from the right
5. View in the direction **e** = view from below
6. View in the direction **f** = view from the rear

Figure (a) shows the relative positions of the above six views in the first angle projection and Fig. (b), the distinguishing symbol of this method of projection. Figure (c) shows the relative position of the views in the third angle projection and Fig. (d), the distinguishing symbol of this method of projection.

NOTE: A comparison of Figs. (a), (b) and (c), (d) reveals that in both the methods of projection, the views are identical in shape and detail. Only their location with respect to the view from the front is different.

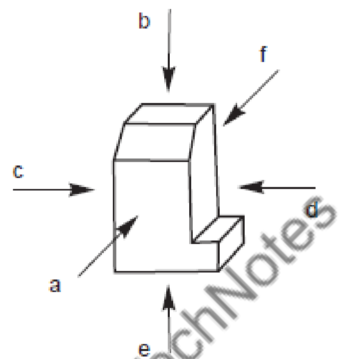
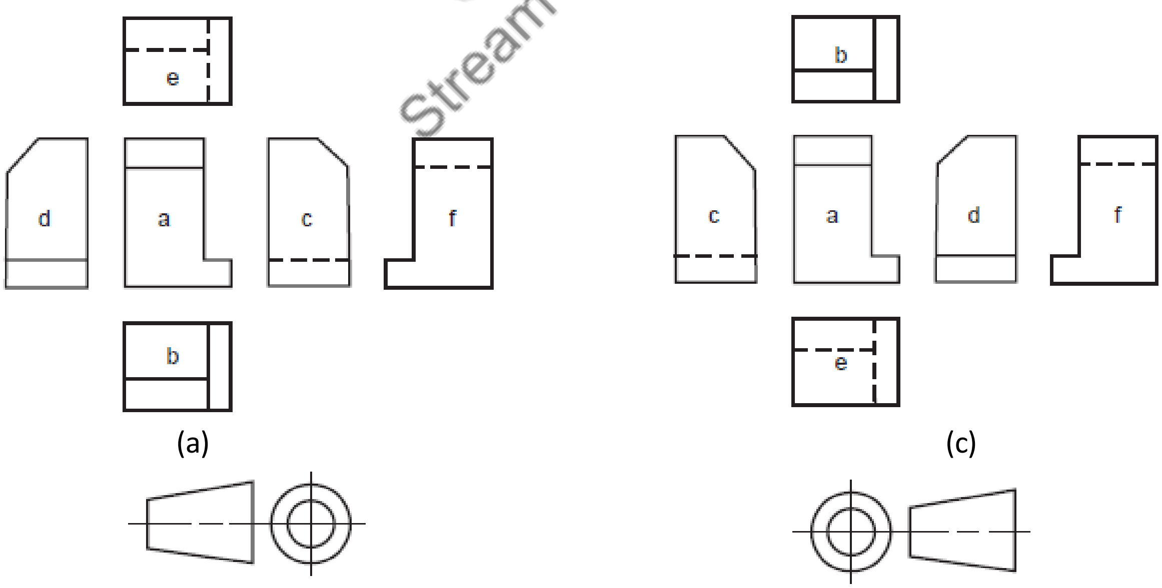


Fig. 5.6 Designation of Views



(a) (c)

(b) Relative positions of six views in first angle projection

(d) Relative positions of six views in third angle projection

Fig. 5.7

Position of the Object

It is important to understand the significance of the position of the object relative to the planes of projection. To get useful information about the object in the orthographic projections, the object may be imagined to be positioned properly because of the following facts:

1. Any line on an object will show its true length, only when it is parallel to the plane of projection.
2. Any surface of an object will appear in its true shape, only when it is parallel to the plane of projection.

In the light of the above, it is necessary that the object is imagined to be positioned such that its principal surfaces are parallel to the planes of projection.

Hidden Lines

While obtaining the projection of an object on to any principal plane of projection, certain features of the object may not be visible. The invisible or hidden features are represented by short dashes of medium thickness. Figure shows the application of hidden lines in the projection of an object.

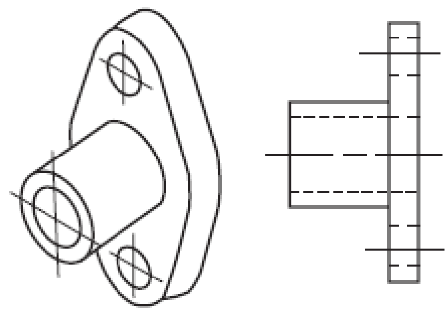


Fig. 5.8 Application of Hidden Lines

Curved Surfaces

Certain objects contain curved surfaces, tangential to other curved surfaces. The difficulty in representing the surfaces can be overcome if the following rule is observed. Wherever a tangential line drawn to the curved surface becomes a projector, a line should be drawn in the adjacent view. Figure shows the representation of certain curved surfaces, tangential to other curved surfaces.

Certain objects manufactured by casting technique, frequently contain corners filleted and the edges rounded. When the radius of a rounded corner is greater than 3 mm and the angle between the surfaces is more than 90°, no line is shown in the adjacent view. Figure shows the application of the above principle.

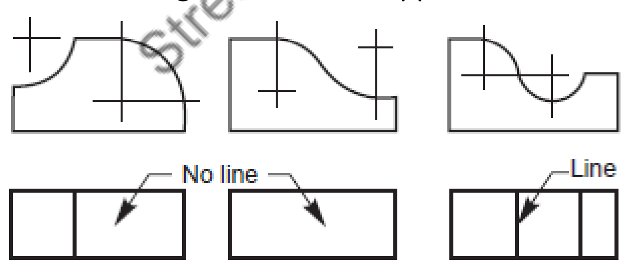


Fig. 5.9 Representation of tangential curved surfaces

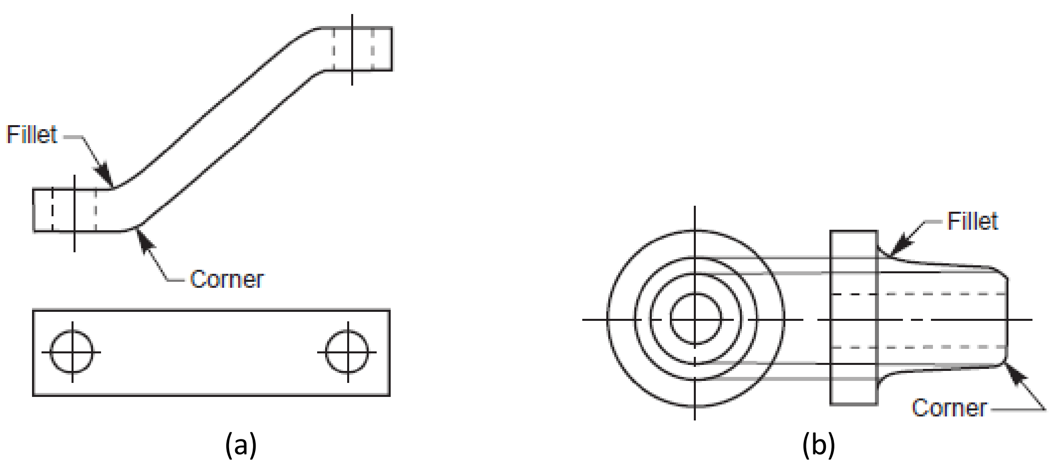


Fig. 5.10 Representation of corners and fillets

If true projection is followed in drawing the view of an object containing fillets and rounds; it will result in misleading impression. In conventional practice, fillets and rounds are represented by lines called run outs. The run outs are terminated at the point of tangency.

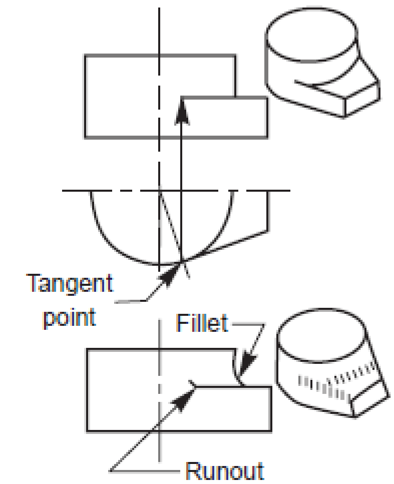


Fig. 5.11 Run outs

Selection of Views

For describing any object completely through its orthographic projections, it is important to select a number of views. The number of views required to describe any object will depend upon the extent of complexity involved in it. The higher the symmetry, the lesser the number of views required.

1. One View Drawings

Some objects with cylindrical, square or hexagonal features or, plates of any size with any number of features in it may be represented by a single view. In such cases, the diameter of the cylinder, the side of the square, the side of the hexagon or the thickness of the plate may be expressed by a note or abbreviation. Square sections are indicated by light crossed diagonal lines. Figure shows some objects which may be described by one-view drawings.

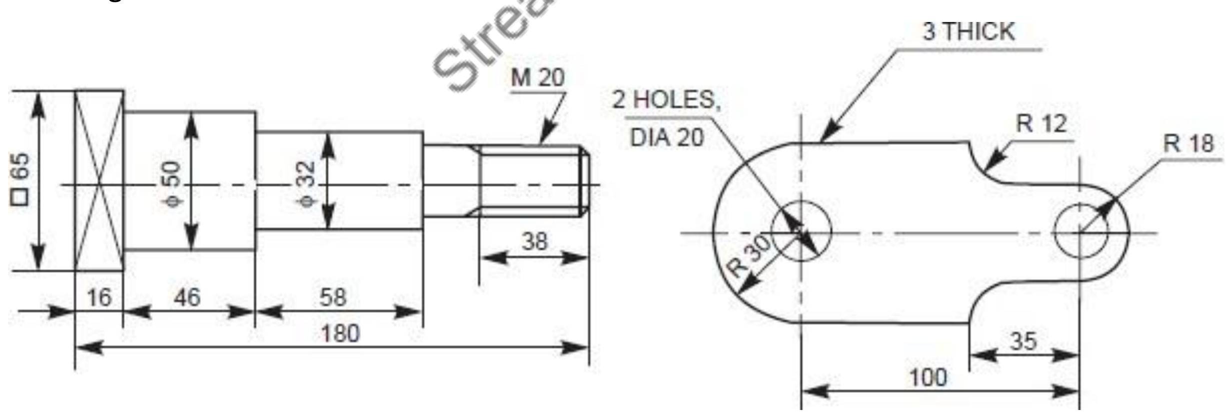


Fig. 5.12 One View Drawings

2. Two – View Drawings

Some objects which are symmetrical about two axes may be represented completely by two views. Normally, the largest face showing most of the details of the object is selected for drawing the view from the front. The shape of the object then determines whether the second view can be a view from above or a side view. Figure shows the example of two-view drawings.

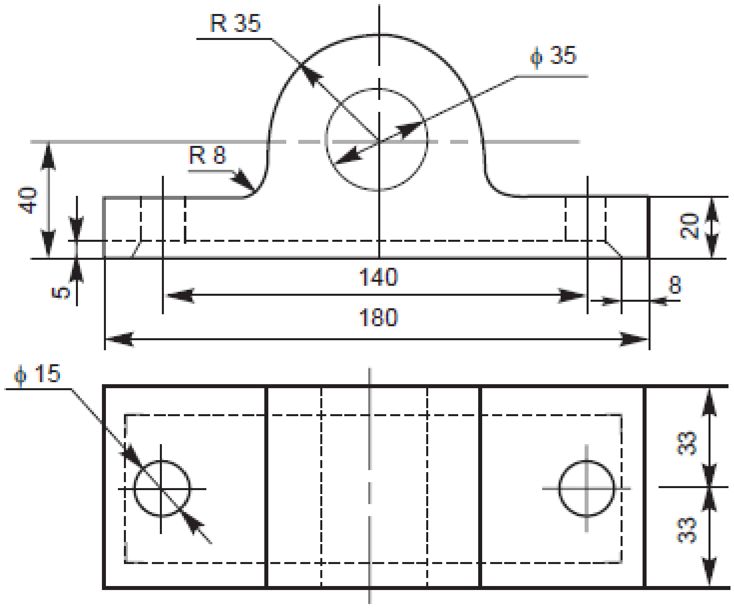
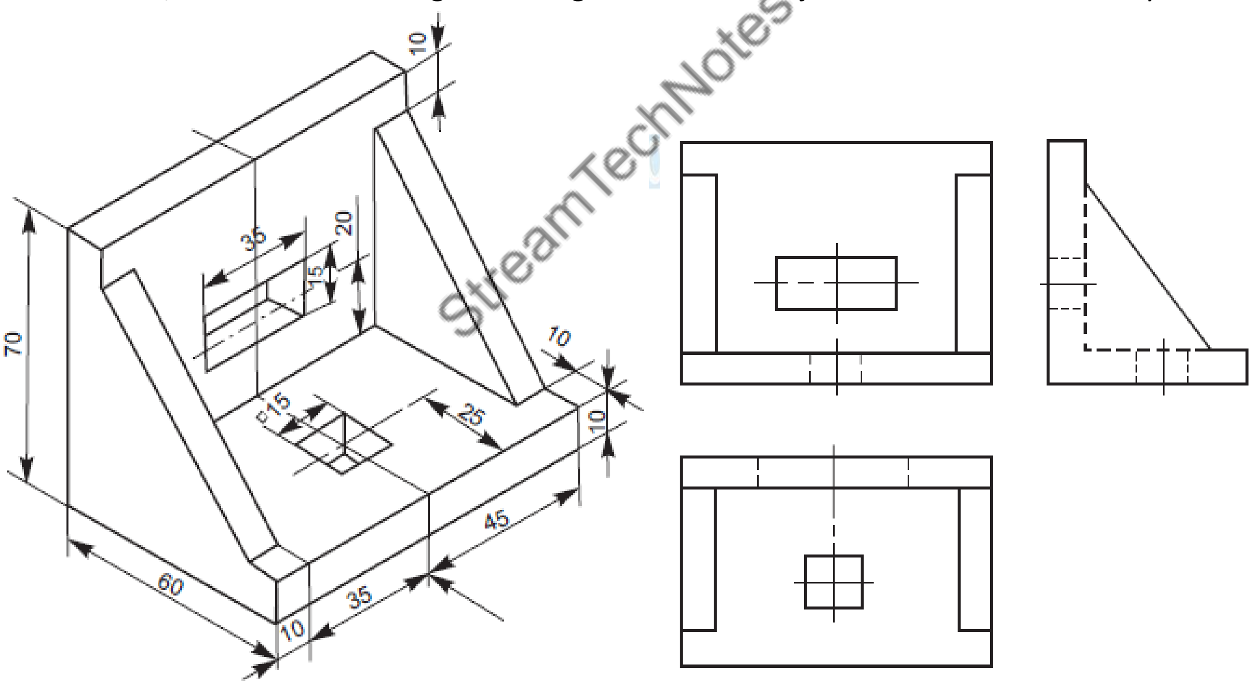


Fig. 5.13 Two – View Drawings

3. Three – View Drawings

In general, most of the objects consisting of either a single component or an assembly of a number of components are described with the help of three views. In such cases, the views normally selected are the views from the front, above and left or right side. Figure shows an object and its three necessary views.



(a) (b)

Fig. 5.14 Three – View Drawing

Examples

NOTE: - For all the examples given, the following may be noted: Arrow indicates the direction to obtain the view from the front.

1.

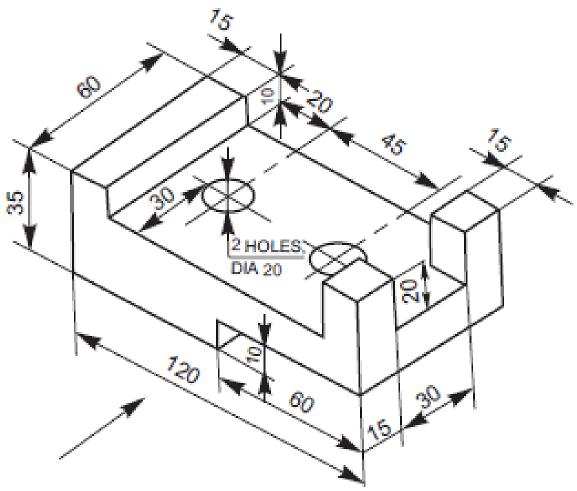


Fig. 5.15

Solution: -

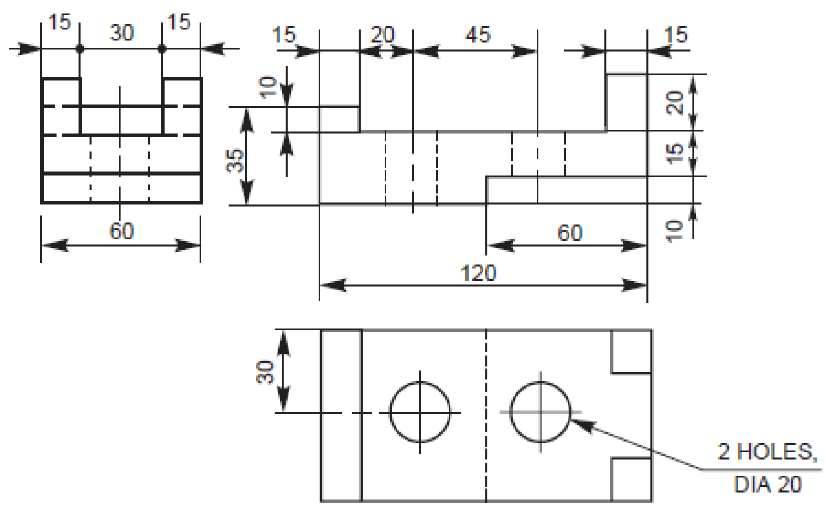


Fig. 5.16

2.

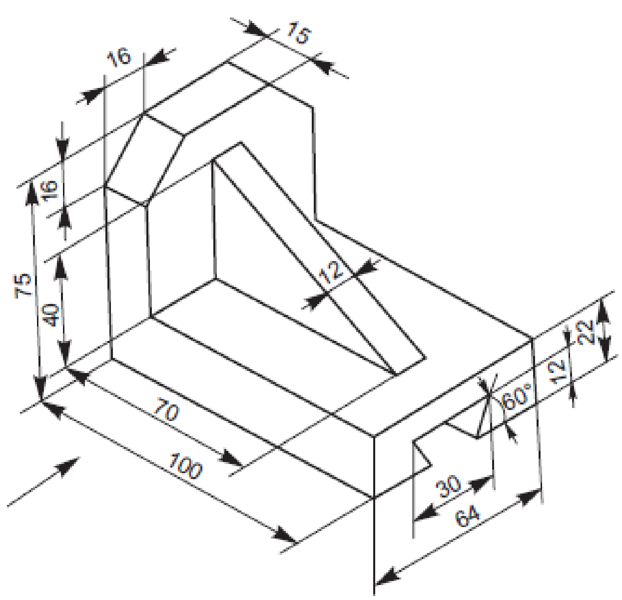


Fig. 5.17

Solution: -

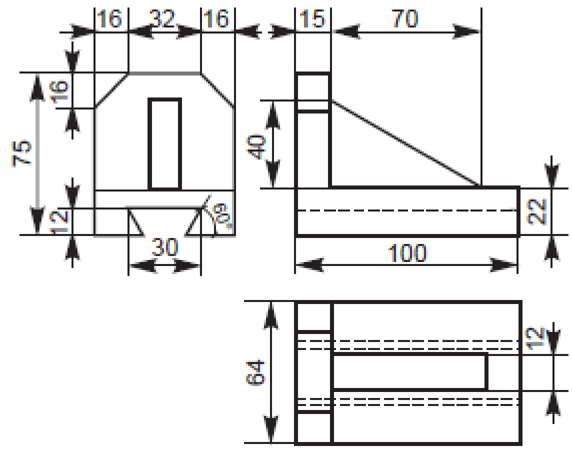


Fig. 5.18

3.

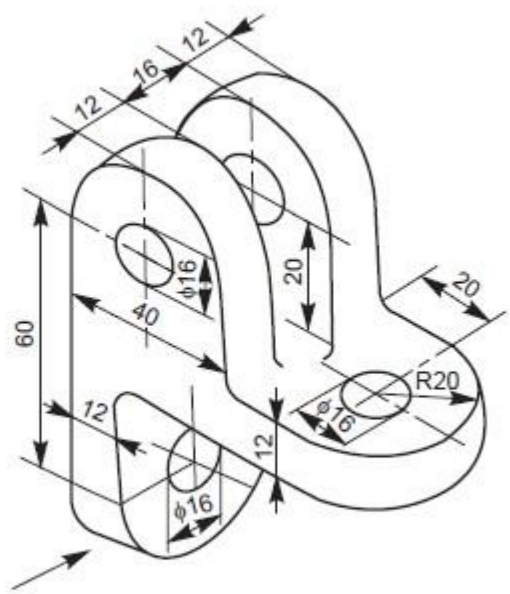


Fig. 5.19

Solution: -

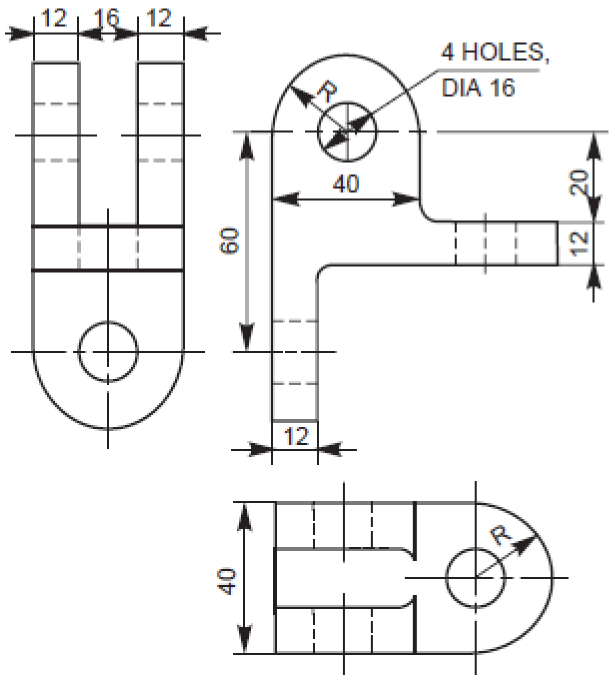


Fig. 5.20

Isometric projections: Isometric scales, isometric views of Simple objects.

Introduction

Pictorial projections are used for presenting ideas which may be easily understood by persons even without technical training and knowledge of multi-view drawing. The Pictorial drawing shows several faces of an object in one view, approximately as it appears to the eye.

Principle of Isometric Projections

It is a pictorial orthographic projection of an object in which a transparent cube containing the object is tilted until one of the solid diagonals of the cube becomes perpendicular to the vertical plane and the three axes are equally inclined to this vertical plane.

Isometric projection of a cube in steps is shown in Fig. Here ABCDEFGH is the isometric projection of the cube.

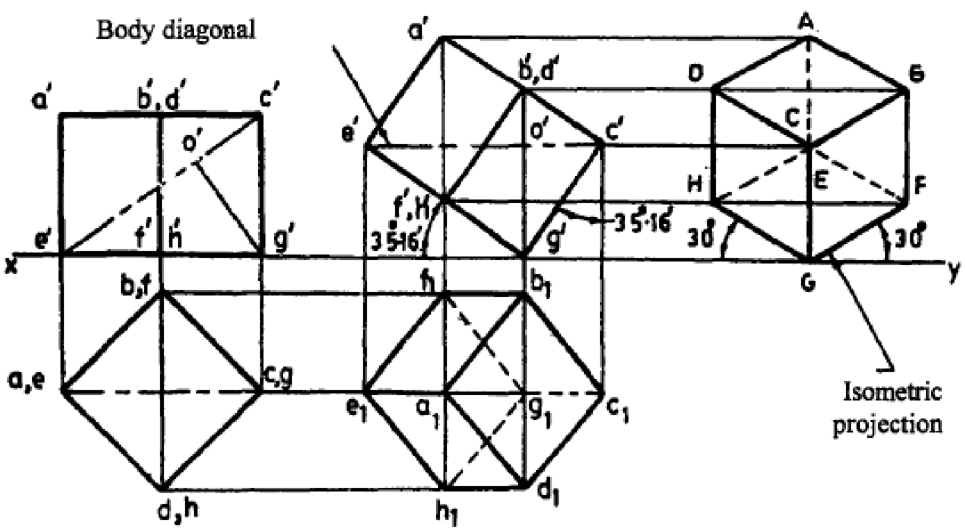


Fig. 5.21 Principle of Isometric Projection

The front view of the cube, resting on one of its corners (G) is the isometric projection of the cube.

Isometric Scale

In the isometric projection of a cube shown in Fig., the top face ABCD is sloping away from the observer and hence the edges of the top face will appear fore-shortened. The true shape of the triangle DAB is represented by the triangle DPB.

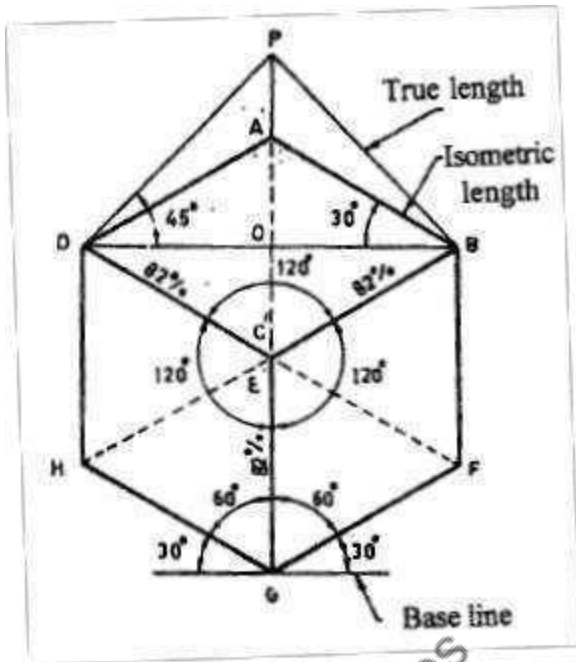


Fig. 5.22 An isometric Cube

The extent of reduction of an isometric line can be easily found by construction of a diagram called isometric scale. For this, reproduce the triangle DPA as shown in Fig. Mark the divisions of true length on DP. Through these divisions draw vertical lines to get the corresponding points on DA. The divisions of the line DA give dimensions to isometric scale.

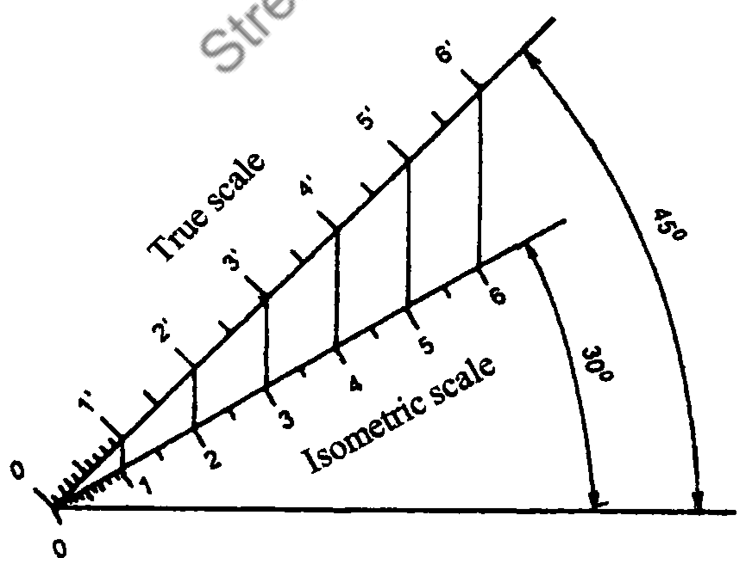


Fig. 5.23 Isometric Scale

From the triangle ADO and PDO in Fig., the ratio of the isometric length to the true length,

i.e., DA/DP = cos 45°/cos30° = 0.816

The isometric axes are reduced in the ratio 1:0.816 i.e. 82% approximately.

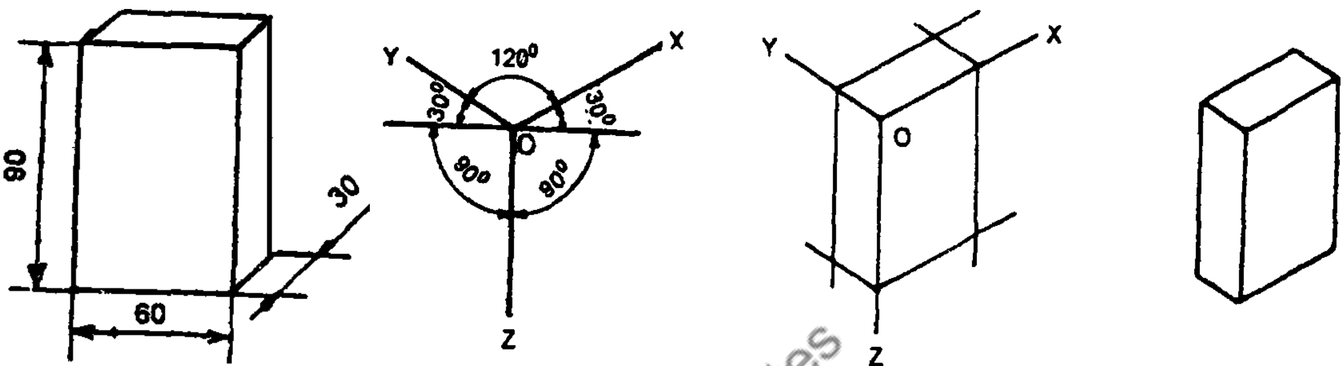
Lines in Isometric Projection

The following are the relations between the lines in isometric projection which are evident from Fig..

1. The lines that are parallel on the object are parallel in the isometric projection.
2. Vertical lines on the object appear vertical in the isometric projection.
3. Horizontal lines on the object are drawn at an angle of 30° with the horizontal in the isometric projection.
4. A line parallel to an isometric axis is called an isometric line and it is fore shortened to 82%.
5. A line which is not parallel to any isometric axis is called non-isometric line and the extents of fore-shortening of non-isometric lines are different if their inclinations with the vertical planes are different.

Isometric Projection

Figure (a) shows a rectangular block in pictorial form and Fig. (b), the steps for drawing an isometric projection using the isometric scale.



(a) (b)

Fig. 5.24 Developing Isometric Projection

Isometric Drawing

Drawings of objects are seldom drawn in true isometric projections, as the use of an isometric scale is inconvenient. Instead, a convenient method in which the foreshortening of lengths is ignored and actual or true lengths are used to obtain the projections, called isometric drawing or isometric view is normally used. This is advantageous because the measurement may be made directly from a drawing.

The isometric drawing of figure is slightly larger (approximately 22%) than the isometric projection. As the proportions are the same, the increased size does not affect the pictorial value of the representation and at the same time, it may be done quickly. Figure shows the difference between the isometric drawing and isometric projection.

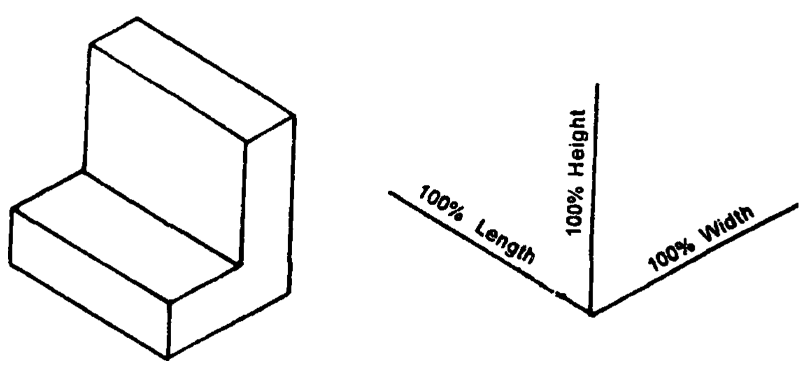


Fig. 5.25 (a) Isometric Drawing

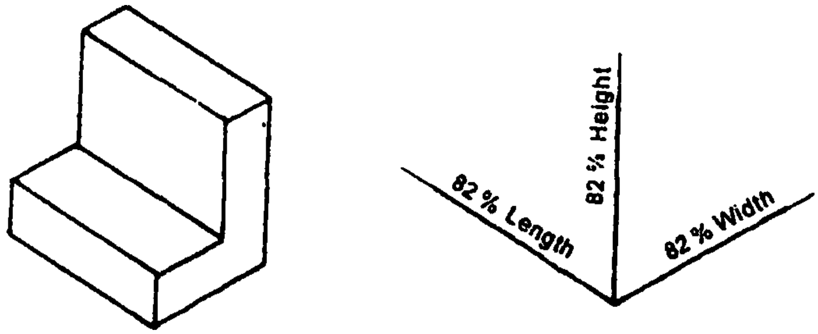


Fig. 5.26 (b) Isometric Projection

Steps to be followed to make isometric drawing from orthographic views are given below (Fig.).

1. Study the given views and note the principal dimensions and other features of the object.
2. Draw the isometric axes (a).
3. Mark the principal dimensions to-their true values along the isometric axes (b).
4. Complete the housing block by drawing lines parallel to the isometric axes and passing through the above markings (e).
5. Locate the principal corners of all the features of the object on the three faces of the housing block (d).
6. Draw lines parallel to the axes and passing through the above points and obtain the isometric drawing of the object by darkening the visible edges (e).

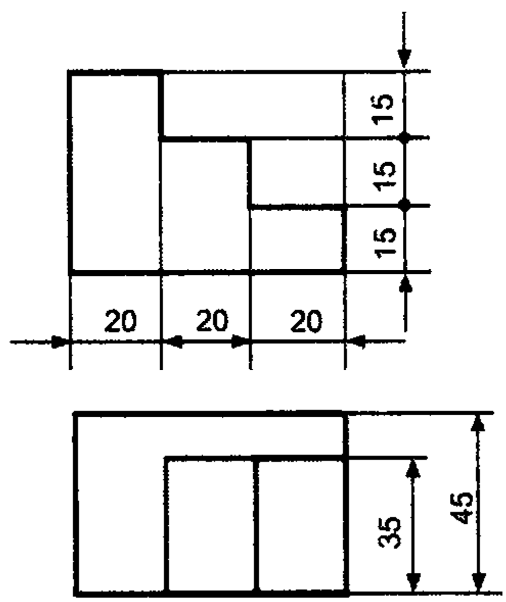
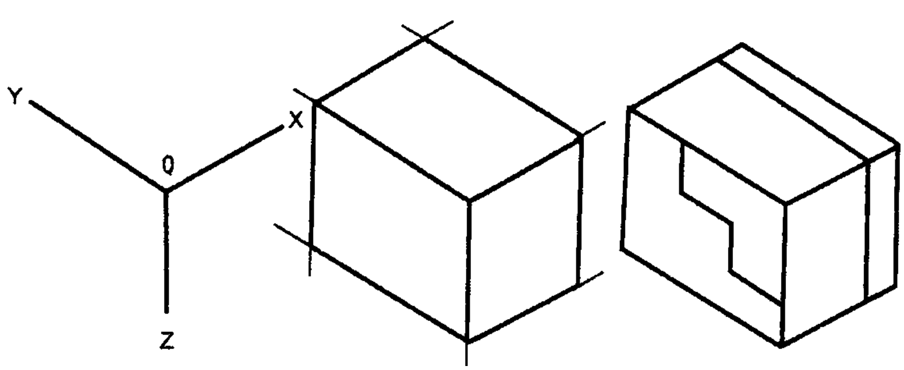
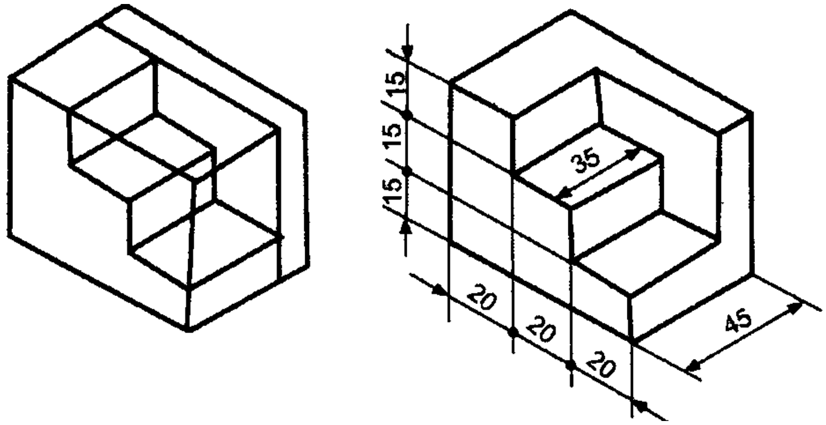


Fig. 5.27 (A) Orthographic View



(a) (b) (c)



(d) (e)

Fig. 5.28 (B) Isometric View

Non-Isometric Lines

In an isometric projection or drawing, the lines that are not parallel to the isometric axes are called non-isometric lines. These lines obviously do not appear in their true length on the drawing and cannot be measured directly. These lines are drawn in an isometric projection or drawing by locating their end points.

Figure shows the isometric drawing of an object containing non isometric lines from the given orthographic views.

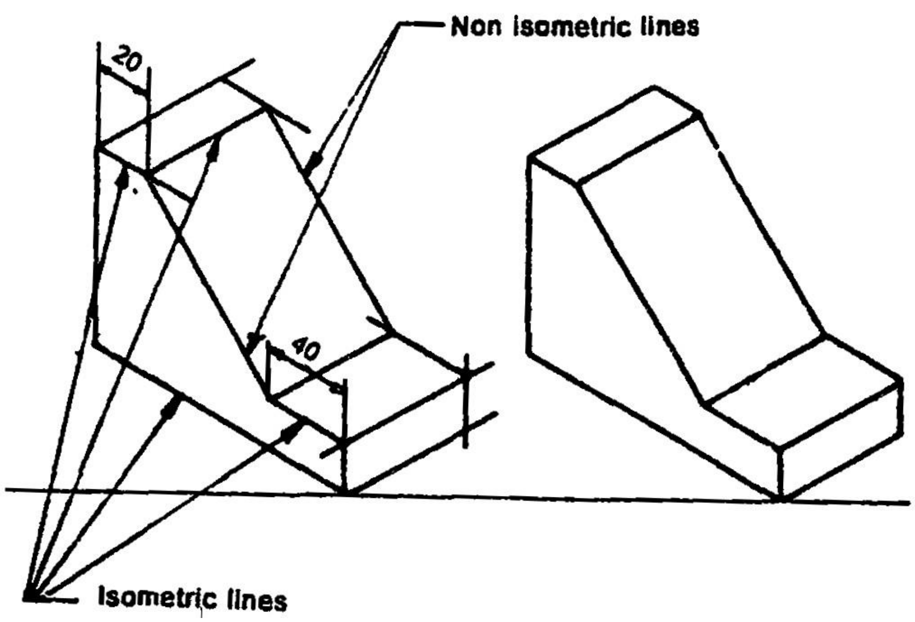


Fig. 5.29

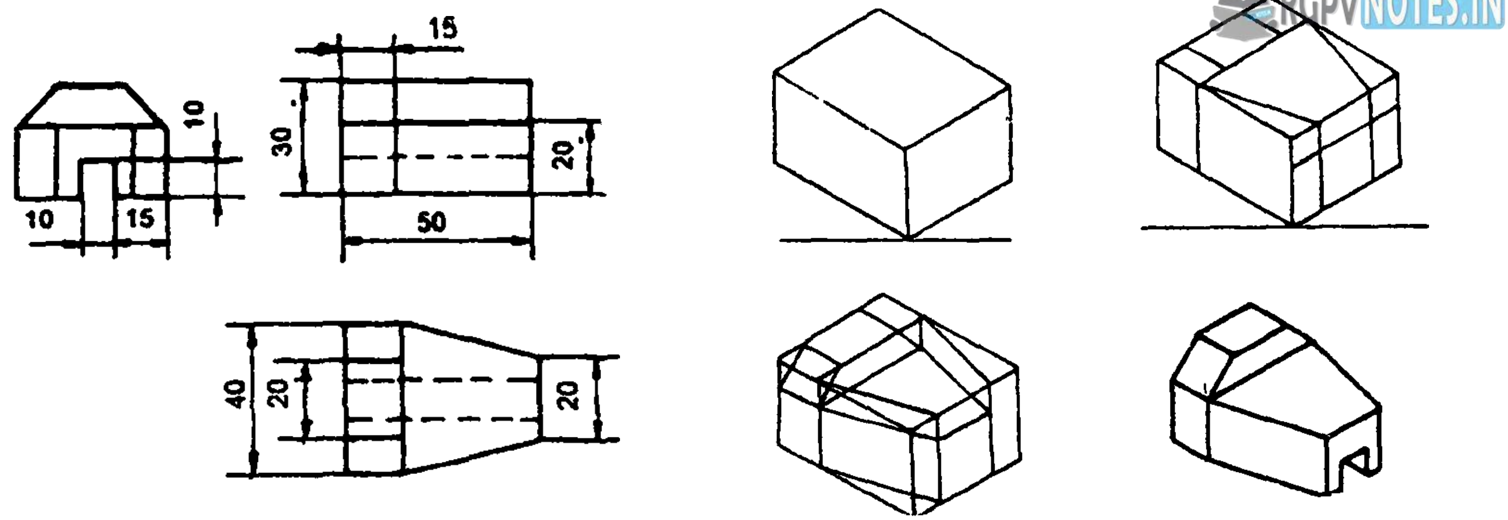
Methods of Constructing Isometric Drawing

The methods used are:

1. Box method.
2. Off-set method.

Box Method

When an object contains a number of non-isometric lines, the isometric drawing may be conveniently constructed by using the box method. In this method, the object is imagined to be enclosed in a rectangular box and both isometric and non-isometric lines are located by their respective points of contact with the surfaces and edges of the box.

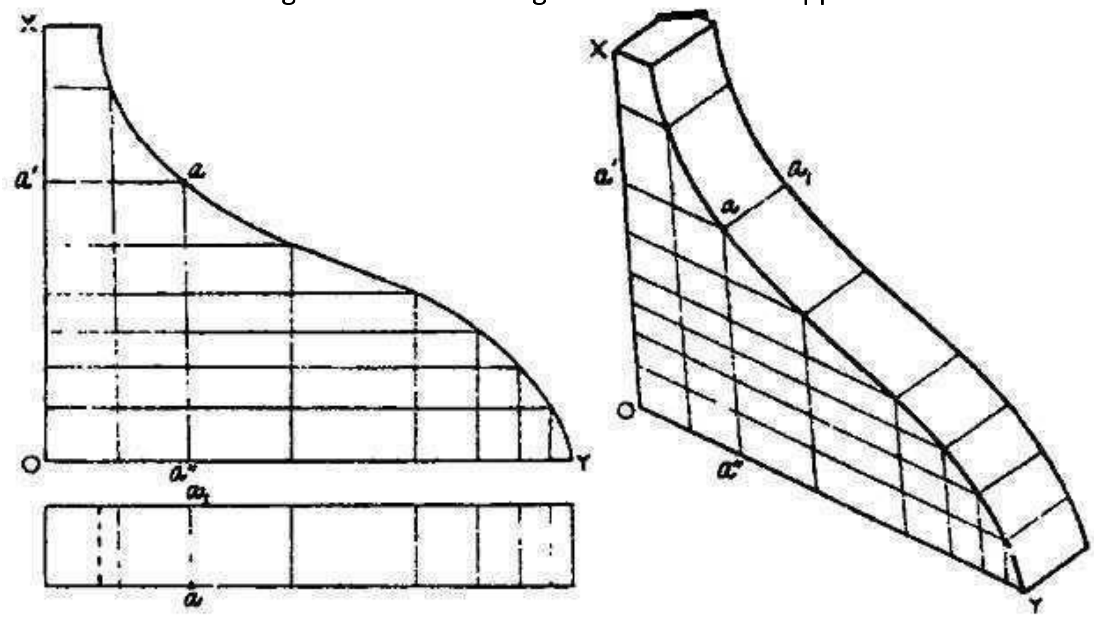


(a) (b)

Fig. 5.30

Off-set Method

Off-set method of making an isometric drawing is preferred when the object contains irregular curved surfaces. In the off-set method, the curved feature may be obtained by plotting the points on the curve, located by the measurements along isometric lines. Figure illustrates the application of this method.



(a) (b)

Fig. 5.31

Isometric Projection of Planes

Problem: Draw the isometric projection of a rectangle of 100mm and 70mm sides if its plane is (a) Vertical and (b) Horizontal.

Construction:-

1. Draw the given rectangle ABCD as shown in Fig. (a).

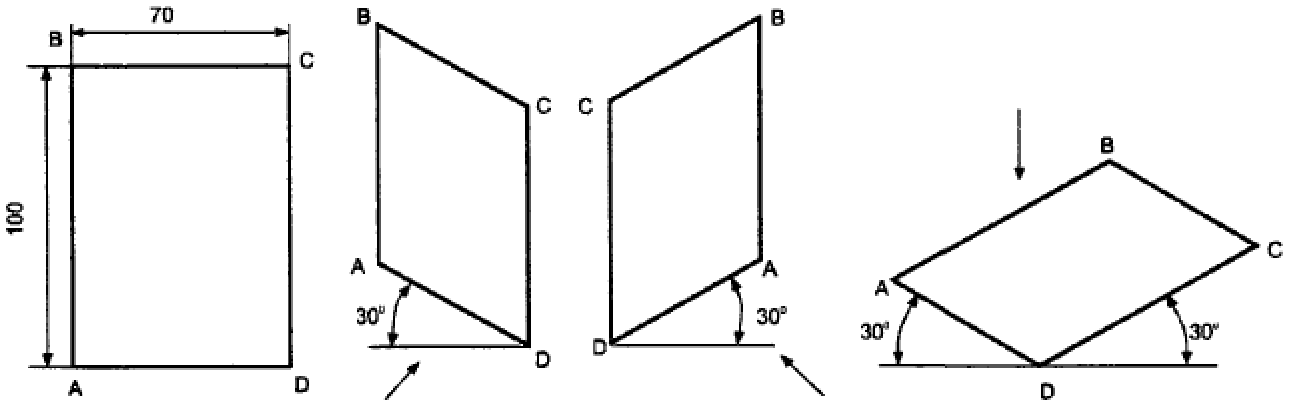
Note:

(i) In the isometric projection, vertical lines are drawn vertical and the horizontal lines are drawn inclined 30° to the base line.

(it) As the sides of the rectangle are parallel to the isometric axes they are fore-shortened to approximately 82% in the isometric projections.

Hence AB = CD = 1000 x 0.82mm = 82mm. Similarly, BC = AD = 57.4 mm.

(a) When the plane is vertical:
2. Draw the side AD inclined at 30° to the base line as shown in Fig. b and mark AD = 57.4mm.
3. Draw the verticals at A and D and mark off AB = DC = 82mm on these verticals.
4. Join BC which is parallel to AD.
ABCD is the required isometric projection. This can also be drawn as shown in Fig. c. Arrows show the direction of viewing.

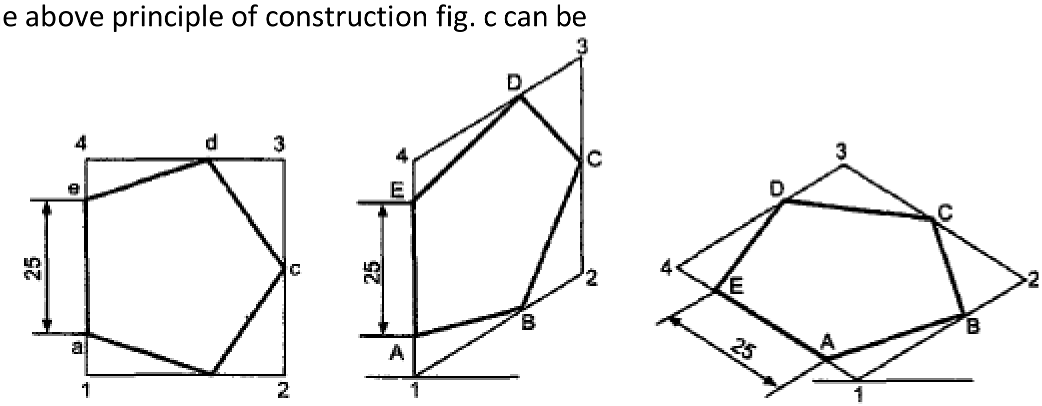


(i) (b) (c) (d)

Fig. 5..32

(a) When the plane is horizontal.
5. Draw the sides AD and DC inclined at 30° to be base line and complete the isometric projection ABCD as shown in Fig. d. Arrow at the top shows the direction of viewing.

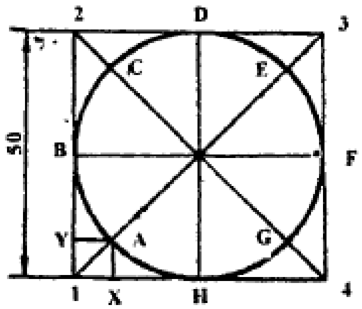
Problem: Figure shows the projection of a pentagonal plane. Draw the isometric drawing of the plane (i) when the surface is parallel to V.P. and (ii) parallel to H.P.
Construction: -
1. Enclose the given pentagon in a rectangle 1234.
2. Make the isometric drawing of the rectangle 1234 by using true lengths.
3. Locate the points A and B such that Ia = lA and 1 b = IB.
4. Similarly locate point C, D and E such that 2c = 2C, 3d = 3D and e4 = E4.
5. ABCDE is the isometric drawing of the pentagon.
6. Following the above principle of construction fig. c can be



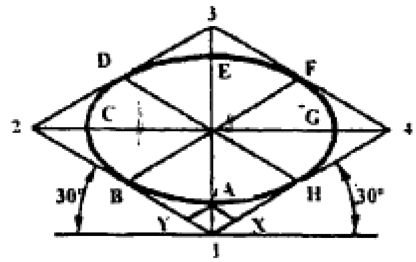
(a) (b) (c)

Fig. 5.33

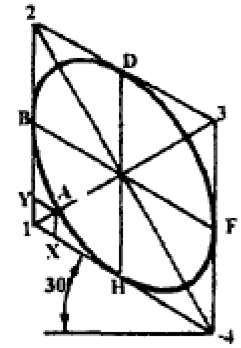
Problem: Draw the isometric view of a circular plane of diameter 60mm whose surface is (a) Horizontal, (b) Vertical.
Construction: - Using the method of points



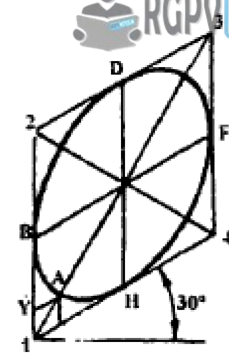
(a)



(b)



(c)



(d)

Fig. 5.34

1. Enclose the circle in a square 1-2-3-4 and draw diagonals, as shown in Fig. 5.34 a. Also draw lines YA horizontally and XA vertically.

To draw the isometric view of the square 1-2-3-4 as shown in Fig. 5.34 b.

2. Mark the mid points of the sides of the square as B, D, F and H.

3. Locate the points X and Y on lines 1-4 and 1-2 respectively.

4. Through the point X, draw AX parallel to line 1-2 to get point A on the diagonal 1-3. The point A can be obtained also by drawing Y A through the point Y and parallel to the line 1-4. S. Similarly obtain other points C, E and G

6. Draw a smooth curve passing through all the points to obtain the required isometric view of the horizontal circular plane.

7. Similarly obtain isometric view of the vertical circular plane as shown in Fig. 5.34 c and d.

Problem: Draw the isometric projection of a circular plane of diameter 60mm whose surface is (a) Horizontal and (b) Vertical-use Four-centre method

Construction: - Using Four – Centre Method

1. Draw the isometric projection of the square 1-2-3-4 (rhombus) whose length of side is equal to the isometric length of the diameter of the circle = 0.82 x 60.

2. Mark the mid points A, B, C and D of the four sides of the rhombus. Join the points 3 and A. This line intersects the line 2-4 joining the point 2 and 4 at M. Similarly obtain the intersecting point N.

3. With centre M and radius = MA draw an arc A B. Also draw an arc C D with centre N.

4. With centre 1 and radius = 1C, draw an ace B C. Also draw the arc A D.

5. The ellipse ABCD is the required isometric projection of the horizontal circular plane (Fig. 5.35 a).

6. Similarly obtain the isometric projection in the vertical plane as shown in Fig. 5.35 b & c.

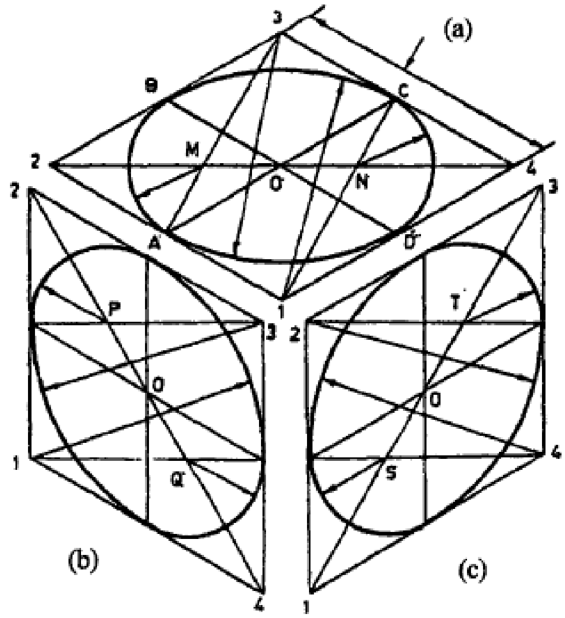


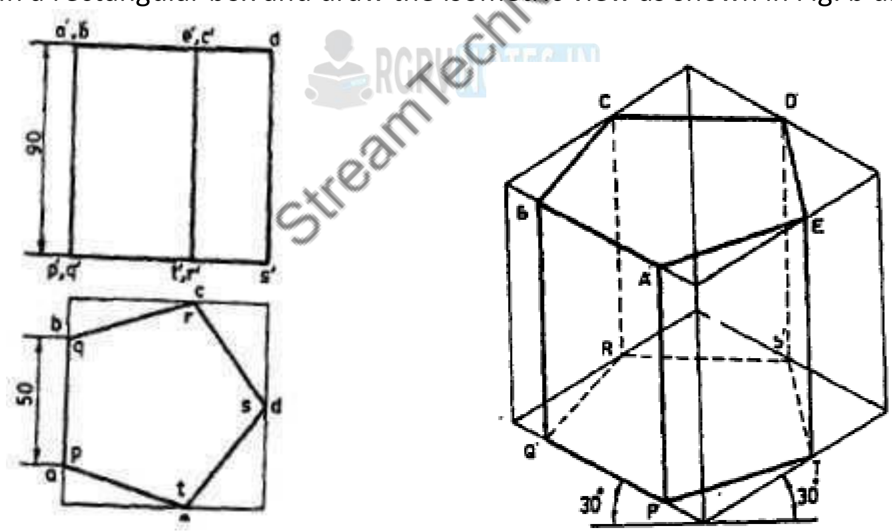
Fig. 5.35

Isometric Projection of Prisms

Problem: Draw the isometric view of a pentagonal prism of base 60 mm side, axis 100 mm long and resting on its base with a vertical face perpendicular to V.P.

Construction: -

1. The front and top views of the prism are shown in Fig. a.
2. Enclose the prism in a rectangular box and draw the isometric view as shown in Fig. b using the box method.



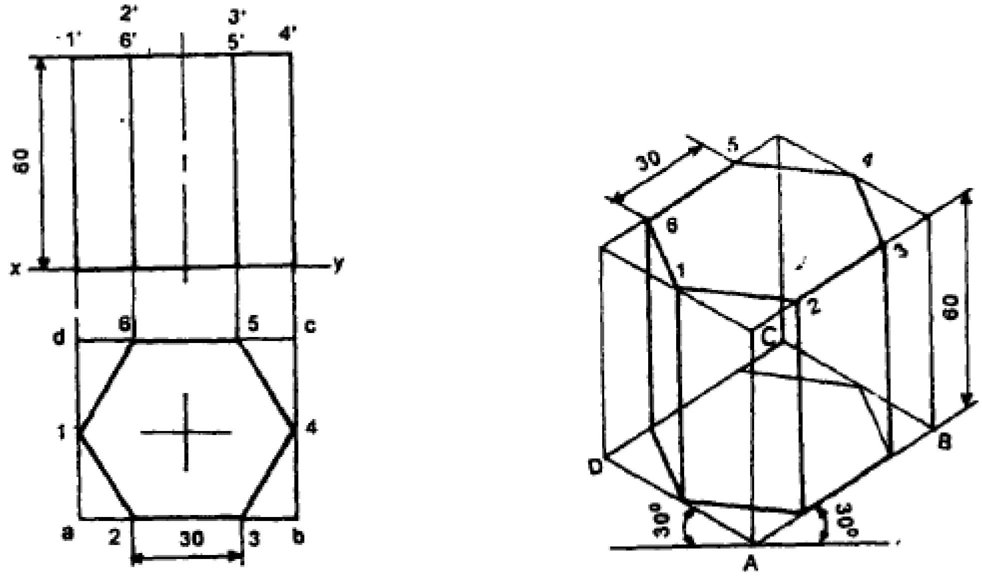
(a) (b)

Fig. 5.36 Isometric Drawing of a Pentagonal Prism

Problem: A hexagonal prism of base of side 30 mm and height 60 mm is resting on its base on H.P. Draw the isometric drawing of the prism.

Construction: -

1. Draw the orthographic views of the prism as shown in Fig. a.
2. Enclose the views in a rectangle (i.e. the top view –base and front views).
3. Determine the distances (off-sets) of the corners of the base from the edges of the box.
4. Join the points and darken the visible edges to get the isometric view.



(a) (b)

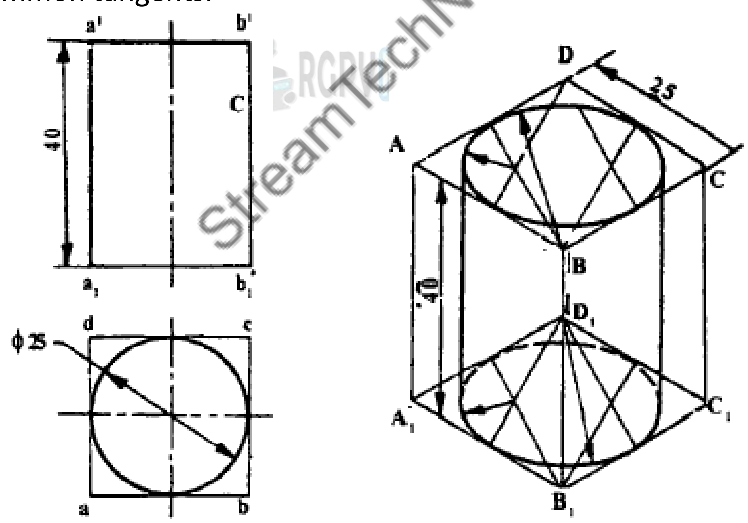
Fig. 5.37 Isometric Drawing of a Hexagonal Prism

Isometric Projection of Cylinder

Problem: Make the isometric drawing of a cylinder of base diameter 20 mm and axis 35 mm long.

Construction: -

1. Enclose the cylinder in a box and draw its isometric drawing.
2. Draw ellipses corresponding to the bottom and top bases by four centre method.
3. Join the bases by two common tangents.



(a) (b)

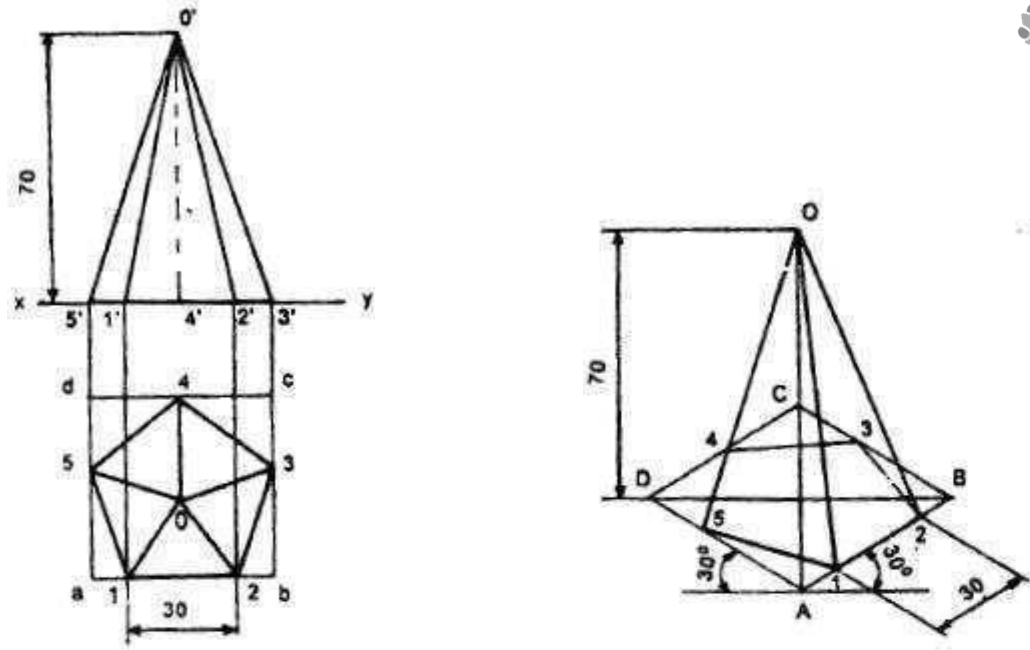
Fig. 5.38 Isometric Drawing of Cylinder

Isometric Projection of Pyramid

Problem: A pentagonal pyramid of side of base 30 mm and height 70 mm is resting with its base on H.P. Draw the isometric drawing of the pyramid.

Construction: -

1. Draw the projections of the pyramid (Fig. a).
2. Enclose the top view in a rectangle abcde and measure the off-sets of all the corners of the base and the vertex.
3. Draw the isometric view of the rectangle ABCD.
4. Using the off-sets locate the corners of the base 1, 2, etc. and the vertex o.
5. Join 0-1, 0-2, 0-3, etc. and darken the visible edges and obtain the required view.



(a) (b)

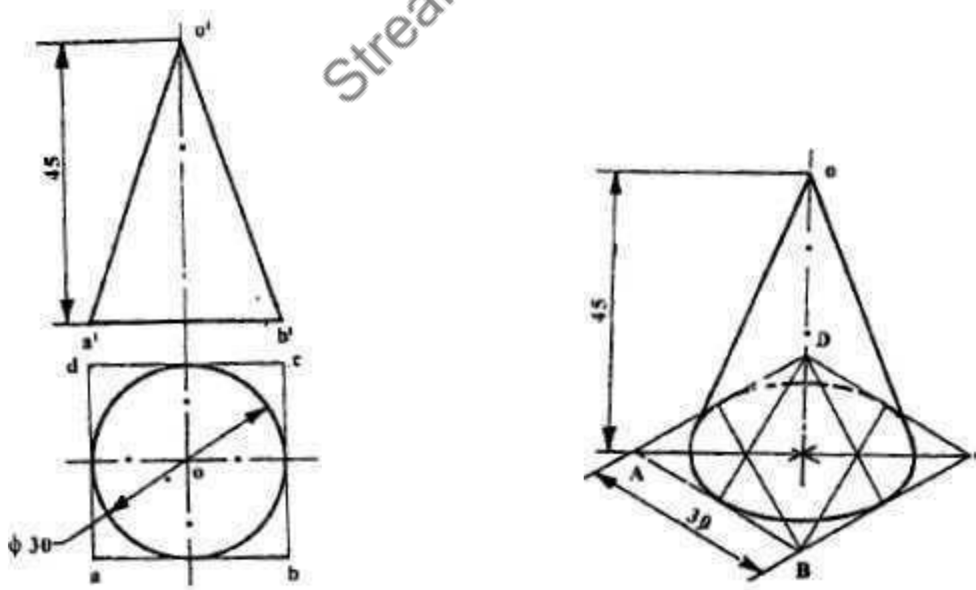
Fig. 5.39 Isometric Drawing of Pentagonal Pyramid

Isometric Projection of Cone

Problem: Draw the isometric drawing of a cone of base diameter 30 mm and axis 50 mm long.

Construction: - Using offset method

1. Enclose the base of the cone in a square (Fig. a).
2. Draw the ellipse corresponding to the circular base of the cone.
3. From the centre of the ellipse draw a vertical centre line and locate the apex at a height of 50 mm.
4. Draw the two outer most generators from the apex to the ellipse and complete the drawing.



(a) (b)

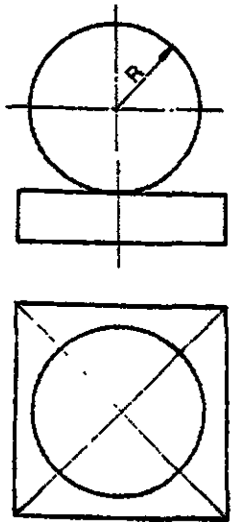
Fig. 5.40

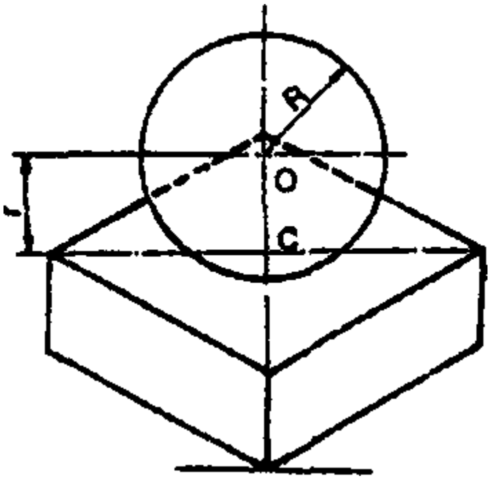
Examples: -

The orthographic projections and the isometric projections of some solids and machine components: -

Note here (a) will be question and (b) will be answer.

1.

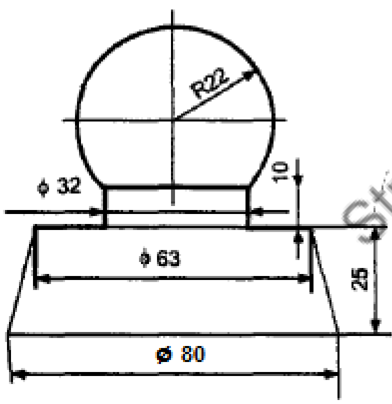


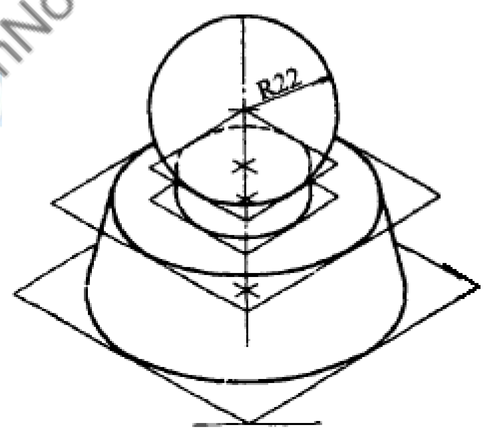


(a) (b)

Fig. 5.41

2.





(a) (b)

Fig. 5.42