LEARNING RESOURCE MATERIAL

ON

Engineering Drawing

UNDER EDUSAT PROGRAMME

SCTE&VT, BHUBANESWAR

ODISHA

CONTENT

CHAPTER-1

Introduction and Demonstration

Drawing board:

A first class engineering drawing board is made of four to six strips of well seasoned soft good quality soft wood such as pine, fir, oak or kill of thickness about 18 mm. The wooden strips are cleated at the back by two battens by means of screws to prevent warping. One of the shorter edges of the rectangular board is fitted with a perfectly straight ebony strip. This edge is used as working edge for the T-square, which moves against the ebony edge.

Followings are the standard sizes of the drawing boards according to the Indian Standard Institution (I. S. I)

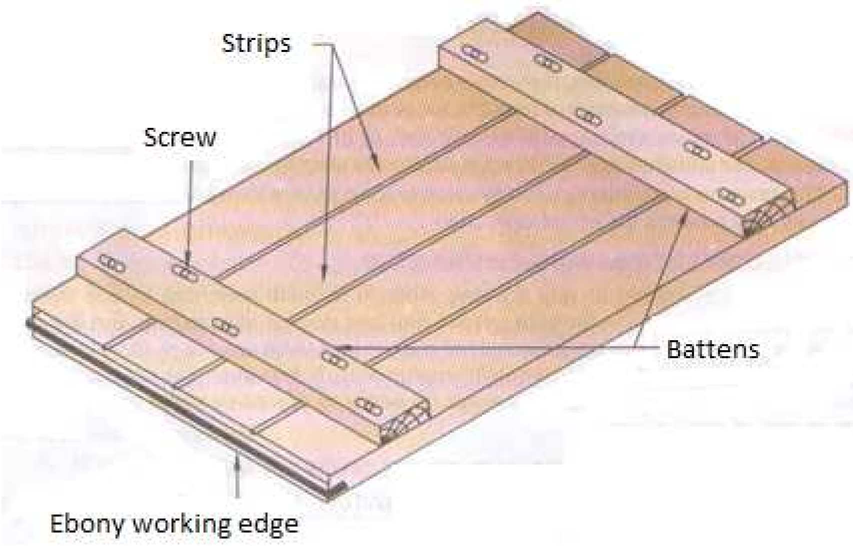


Figure 1: Drawing board

Sl. No.	Designation	Size in mm (Length X width X thickness)	To be used with sheet sizes
1	D_0	1500x1000x25	A_0
2	D_1	100x700x25	A_1
3	D_2	700x500x15	A_2
4	D_3	500x350x15	A_3

Drawing sheet

Different qualities of drawing sheets are available in the market. Depending upon the nature of the drawing the qualities of drawing papers are selected. The drawing paper should be of uniform thickness and of such quality that erasing should not have leave any impression on it. One of the sides of the drawing paper is usually rough and the other smooth. The smooth surface is the side for the drawing work.

Drawing sheets of different sizes are available. Figure 2 shows the drawing sheets of various sizes such as A_0, A_1, A_2, A_3, A_4 and A_5 according to the Indian Standard Institution (I.S.I). The standard sizes of trimmed and untrimmed drawing sheets according to the Indian Standard Institution (I.S.I) are given in the Table 2.

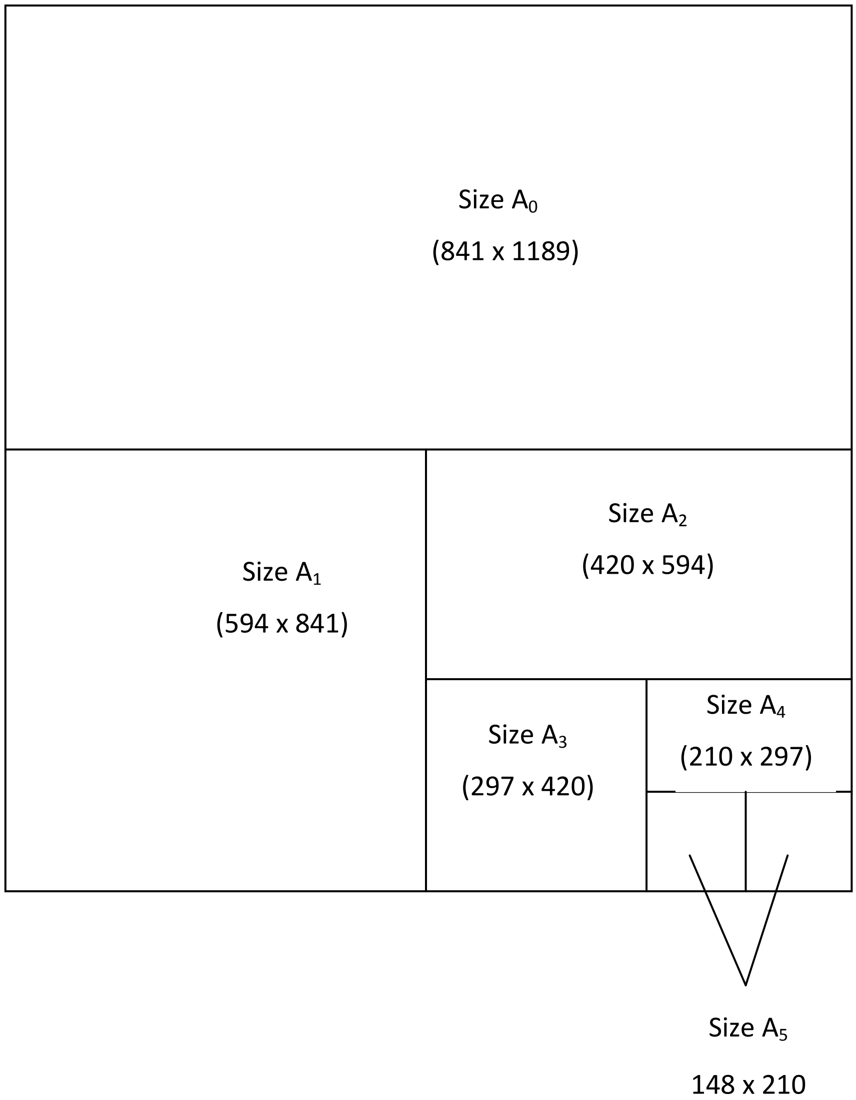


Figure 2: Standard size of drawing sheets according to I.S.I

Table 2: Standard sizes of trimmed and untrimmed drawing sheets

Sl. No.	Designation size in mm	Trimmed size in mm (Width x Length)	Untrimmed size in mm Width x Length
1	A_0	841 x 1189	800 x 1230
2	A_1	594 x 841	625 x 880
3	A_2	420 x 594	450 x 625
4	A_3	297 x 420	330 x 450
5	A_4	210 x 297	240 x 330
6	A_5	148 x 210	165 x 240

Drawing instruments and other drawing materials:

Following is the list of instruments and other ancillary accessories required for construction of drawing.

1. Drawing board
2. T-square
3. Set-squares
4. Compass
5. Divider
6. Protractor
7. Scale
8. Pencil
9. Rubber pr eraser
10. Drawing clips/Drawing pins
11. Duster or handkerchief
12. Mini-drafter

1. Drawing board

The details of drawing board have been discussed in the previous article.

2. T-square

T-square is made of hard quality wood such as teak or mahogany, etc. These are two essential parts of T-square, namely stock and blade. The blade is fitted with an ebony or plastic piece to form working edge of T-square. The two parts are held securely together at right angles to each other by means of screws or dowel pins in order to form a straight edge of blade as shown in the Figure. The working length of the T-square is equal to the length of the drawing board.

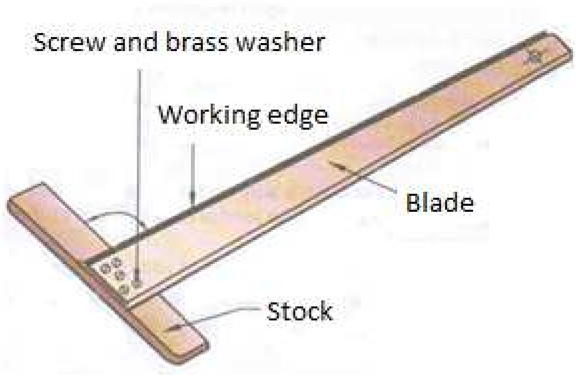


Figure 3: T-square

3. Set squares

Set squares are triangular in shape and are made of celluloid or plastic materials. Set squares made of transparent celluloid are the most satisfactory ones as the lines underneath them can be seen quite easily. Generally two types of set squares are in use. There are: (i) thirty-Sixty degree (30^0-60^0) set square and (ii) Forty five degrees (45^0) set square. The 30^0-60^0 set square has three angles with the measures of 30^0, 60^0 and 90^0 respectively. Similarly, the 45^0 set square has three angles with the measures of 45^0, 45^0 and 90^0 respectively.

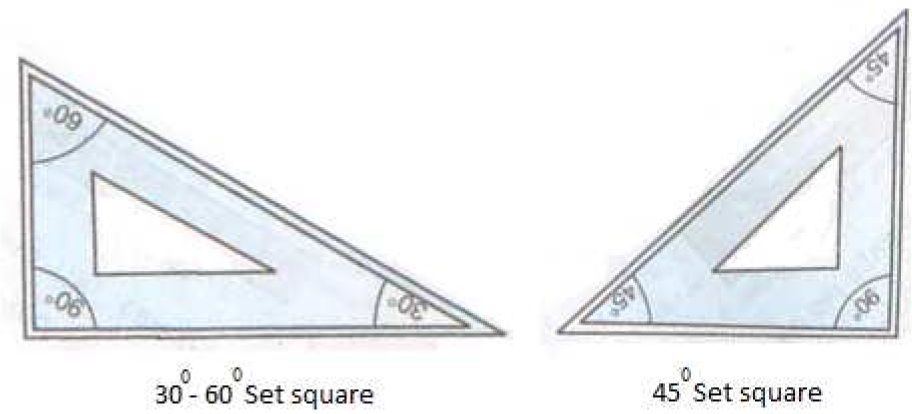


Figure 4: Sets square

Set squares of different sizes are available in the market. Set squares are used for drawing all straight lines except the horizontal lines which are drawn with T-square or mini-drafter as the case may be. Perpendicular lines or the lines at 30^0, 60^0 and 90^0 to the horizontal line can be drawn by using set squares.

4. Compass

Compass is used for drawing circles and arcs of circles of required diameter. It consists of two metal legs hinged together at its upper end by means of joint known as knee joint. An adjustable or fixed needle is fitted on to the end of one of the legs whereas the other leg is provided with an attachment which can be fitted with a pencil lid or pencil depending upon the nature of attachment. There are different types of compass available in the market depending upon their sizes, such as (i) large size compass and (ii) small size compass. Circles up to 120 mm diameters are drawn by keeping the legs of compass straight. For drawing circles more than 150 mm radius, a lengthening bar is used. It is advisable to keep the needle end about 1mm long compared to that of pencil end so that while drawing circles, when the needle end is pressed it goes inside the drawing sheet by a small distance (approximately 1mm).

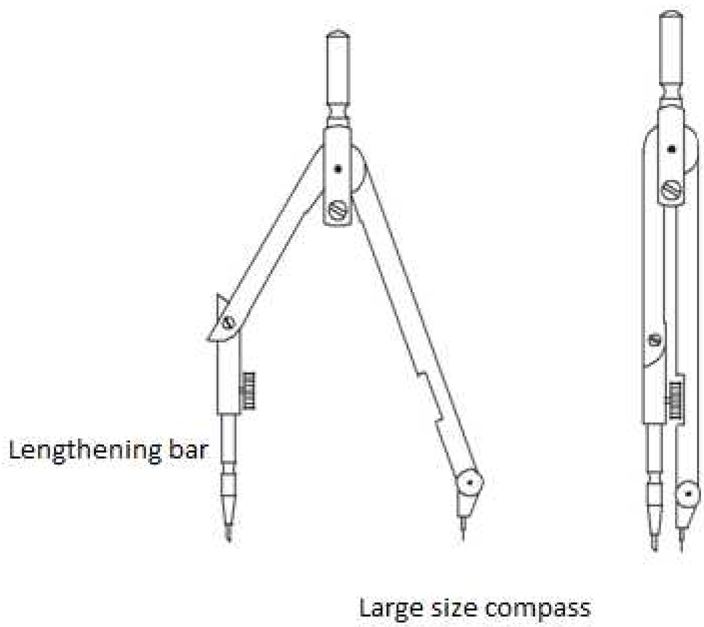


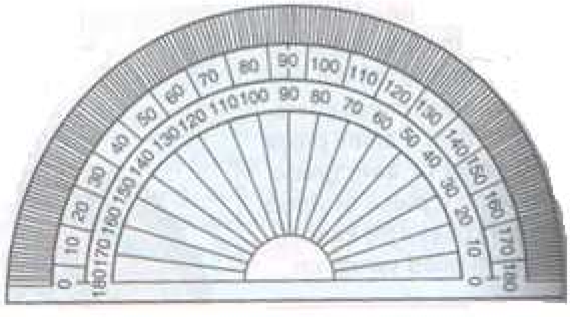
Figure 5: Compass

5. Divider

The divider is used to divide straight or curved lines into desired number of equal parts. It consists of two metal legs as in the compass. However, unlike compass, a divider is provided with two needles on both the legs.

6. Protractor

Protractors are used for constructing and measuring angles. Protractors are generally semicircular in shape. The base diameter of the semicircle serves as the straight edge. A semicircular protractor can measure and angles of any measure between 0^0 to 180^0. Least count of the protractor is generally 1^0.Like set square protractor is also made of transparent celluloid or plastic material.



Semi-circular protractor

Figure 6: Protractor

7. Scales

Scales are used for measurement of lengths and distances on the drawing. Scale is a measuring stick, graduated on both its edges with different divisions to represent the corresponding actual distances of ground according to some fixed proportions. Such scales are known as RF scales or representative fraction scales. Such scales facilitate rapid marking off distances on drawing.

Scales of various representative fractions (RFs) are available in the market e.g., 1:1, 1:2, 1:5, 1:10, 1:20, 1:25, 1:50, 1:100, 1:200, 1:500, 1:1000, etc. the proportion 1:50 means that 50 units on the ground is represented by 1 unit in the drawing.

The scales used in the engineering practice according to I.S.I are:

Full size scale	Reducing scale		Enlarging scale
1:1	1:2	1:25	10:1
	1:5	1:50	5:1
	1:10	1:100	2:1

Scales are used to:

a. Prepare or enlarge the drawing
b. Set off dimension
c. Measure distances directly

8. Pencils

The pencils are used for preparing the drawings on the drawing sheet. The accuracy and the appearance of the drawing depend upon the quality of pencil used. Different grades of pencils are available depending upon the hardness of the lid. Pencils of various grades can be easily recognised by the letters marked on the body of the pencil.

The pencils are generally graded as H, F, B and HB. H represents hardness; F represents firm, B represents softness and HB represents intermediate between hard and soft. The general designation of a pencil is associated with alpha-numeric symbols such as 2H, 3H, HB, B, 2B, 3B, etc. Figure Xx shows various grades of pencils. Drawing pencils are graded as 7B, 6B, ... , HB, H, 2H, ... in the increasing order of their hardness and decreasing order of their blackness. Generally drawings are made with 2H pencils and finished with H or HB pencils.

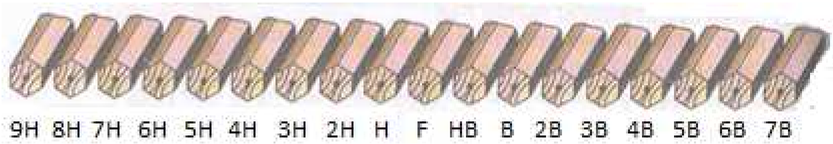


Figure 7: Pencils

9. Rubber or Eraser

An eraser is made of rubber and is used to erase extra pencil work and/or wrongly drawn lines. Soft eraser is the most suitable one for erasing as it leaves a little or no impression on the drawing sheet.

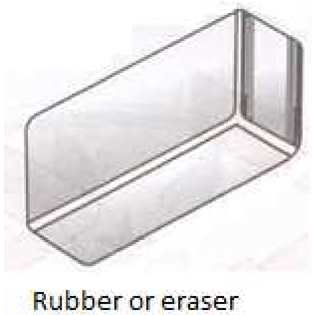


Figure 8 Rubber or eraser

10. Drawing clips or Drawing pins

Both drawing clips and drawing pins serve the same purpose. They are used to fix the drawing sheet firmly in position to the drawing board as one construct the drawing.

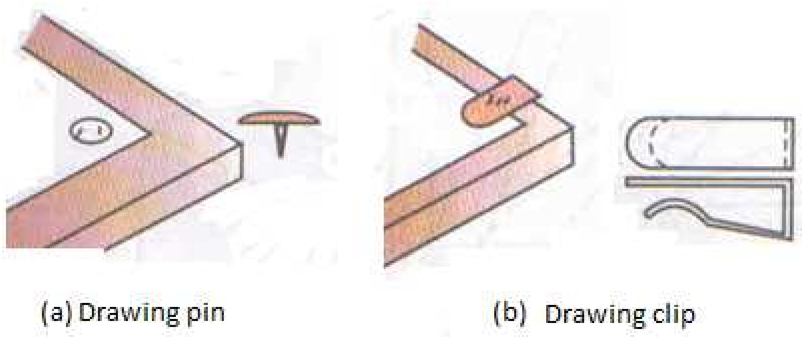


Figure 9 Drawing pins and Drawing clips

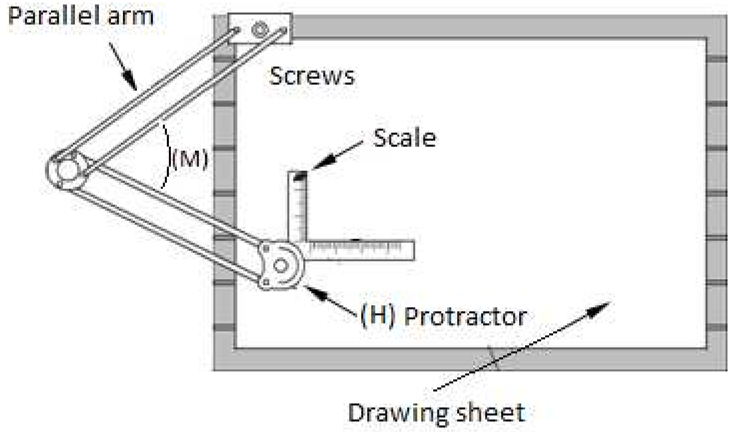
11. Duster or handkerchief

A Duster or a handkerchiek is used for cleaning instruments. It is also used to sweep away the crumps or dusts formed after the use eraser on the drawing sheet.

12. Drafting machine / Mini-drafter

A mini-drafter is an instrument which combines together all the features of a T-square, set squares, scales and protractor and hence is a unified instrument capable of performing the functions of all these instruments put together. One end of the mini-drafter is clamped by means of a screw, to the distant longer edge of the drawing board. At its other end, an adjustable head (H) having protractor markings is fitted. Two blades (B) of transparent celluloid accurately set at right angles to each other are attached to the head.

The machine has a mechanism (M) which keeps the two blades always parallel to their original position, irrespective of their position on the board. The blades have scales marked on them and are used as straight edges. The blades may be set at any desired angle with the help of the protractor markings.



Mini-drafter clamped to the drawing board attached with drawing sheet

Figure 10: Mini-drafter

CHAPTER-2

Types of Lines, Lettering & Dimensioning

OBJECTIVE:

Engineering drawing consists of organized combination of different types of lines. The objective of this chapter is, therefore, to acquaint the students with various types of lines and their relative importance as far as the whole drawing is concerned. Lettering plays an important role as far as logical comprehension of the drawing is concerned, particularly for those parts of the drawing which cannot be shown by lines. A well meaning drawing must be associated with clean dimensioning with good letter quality. Therefore, lettering should be lucid, legible, and uniform in appearance and easy-to-write for rapid freehand writing. After the completion of the chapter, the students can interpret and acknowledge the significance of the lines and also importance of lettering in the larger perspective of quality and comprehensive drawing.

Lines:

Various types of lines used in general engineering drawing as described by B.I.S. S.P: 46 - 1988 are demonstrated in the Fig.

1. Outlines: Lines drawn to represent visible edges and surface boundaries of objects are known as outlines or object lines or principal lines. These are represented by continuous thick lines.

2. Dimension lines: Continuous thin lines, used for giving dimensions of the drawing, are known as dimension lines. A dimension line is terminated at its outer end with an arrow head touching the outline, extension line or centre line.

3. Extension lines or projection lines: These are continuous thin lines used for dimensioning an object. They extend by about 3 mm beyond the dimension lines.

4. Construction lines: These are thin continuous lines used for construction of objects.

5. Section lines or Hatching lines: These are thin continuous lines used for showing the section evidently. They are uniformly spaced thin lines drawn at an angle of 45 degree to the main outline of the section. The spacing between the lines is generally 1 mm to 2 mm.

6. Leader or pointer lines: These are continuous thin lines and are drawn to connect a note with the specific feature in the drawing.

7. Short-break lines: These are continuous, thin and wavy freehand lines drawn to show the break of an object for a short length. These are also used to show irregular boundaries.

8. Long-break lines: these are thin ruled lines provided with short zigzags at suitable intervals. They are drawn to show long breaks.

9. Hidden or Dotted lines: These are closely and evenly spaced dashes lines of equal lengths. They are of medium thickness and are used to show the invisible or hidden parts of the of the object on the drawing.

Table 2.1 Convention of various types of lines according to BIS SP: 46 - 1988

	Continupous thick	Visible outlines Visible edges
	Continuous thin	Imaginary lines of intersection Dimension lines Projection lines Leader lines Hatching Short centre lines
	Continuos thin with zigzags	Long-break line
	Dashed thick	Hidden outlines Hidden edges
	Dashed thin	Hidden outlines Hidden edges
	Continuous thin freehand	Limits of partial or interrupted views and sections, if the limit is not a chain thin line
	Chain thick	Indications of lines or surfaces to which a special requirement applies
	Chain thin	Centre line Line of symmetry Trajectories
	Chain thin, thick at ends and change of direction	Cutting planes
	Chain thin double- dashed	Outlines of adjacent parts Centroidal lines Parts situated in front of the cutting plane

10. Centre lines: These are thin, long, chain lines composed of alternatively long and short dashes spaced at an approximate distance of 1 mm. The proportion of long and short dashes is 6:1 to 8:1. The short dashes are about 1.5 mm long. These are used to indicate the axes of cylindrical, conical and spherical objects. These are also used to show the centres of circles and arcs. Centre lines should extend for a short distance beyond the outlines to which they refer. Locus lines, extreme positions of movable parts and pitch circles are also shown by these lines.

11. Cutting-plane lines: These are long, thin chain line with thick ends. These are used to show the location of cutting plane.

12. Chain thick: These lines are used to indicate special treatment on the surface.

13. Chain thick double-dashed: These lines are used to show outlines of adjacent parts, alternative and extreme positions of movable parts, centroidal lines and parts situated in front of the cutting plane.

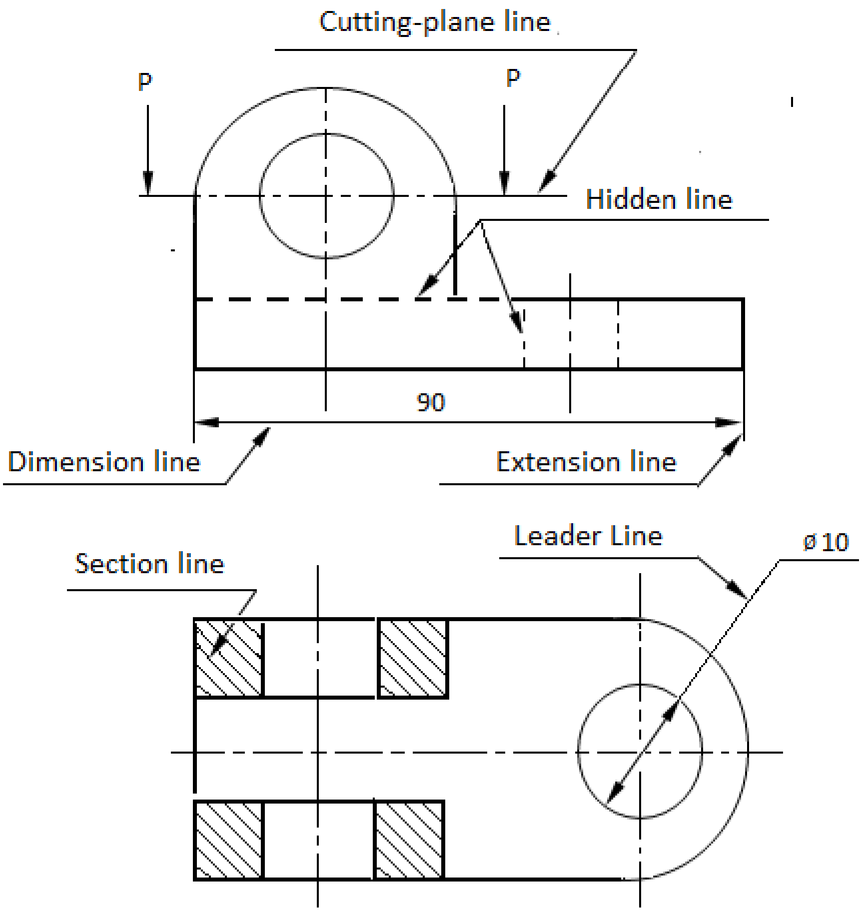


Figure 1

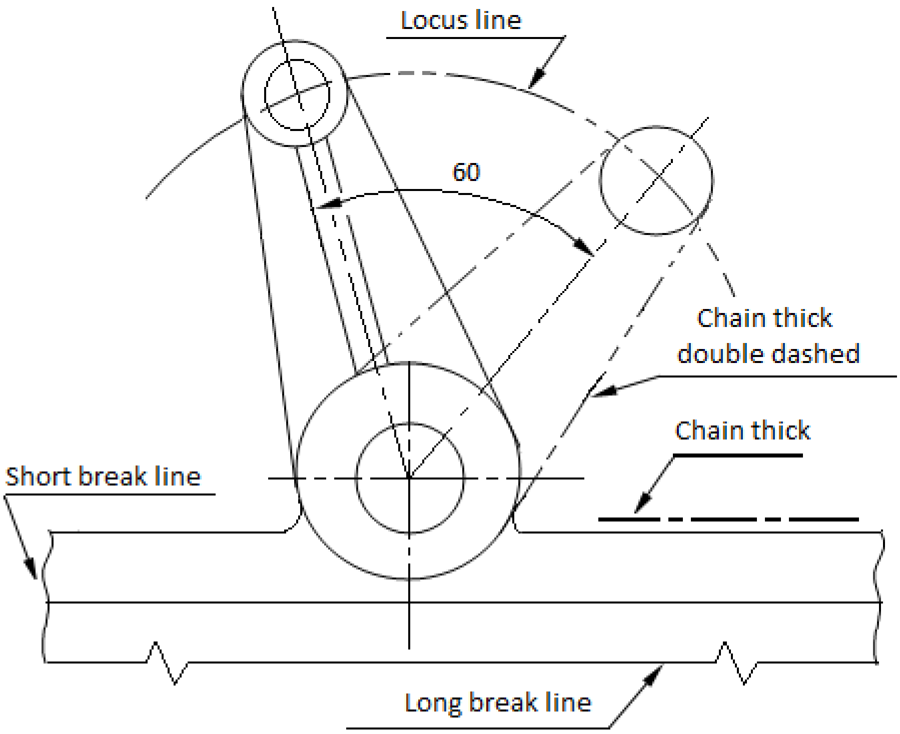


Figure 2

Lettering:

The verbal information, in writing, given in the drawing is known as lettering. Lettering plays an important role as far as logical comprehension of the drawing is concerned, particularly for those parts of the drawing which cannot be shown by lines. A well meaning drawing must be associated with clean dimensioning with good letter quality. Therefore, lettering should be lucid, legible, and uniform in appearance and easy-to-write for rapid freehand writing.

The art of writing letters such as alphabets and numbers etc. is known as lettering. Lettering forms an important part of drawing and is used to write letters, dimensions, notes and such other necessary information as may be required for complete execution of the drawing of an object.

It must be kept in mind that use of drawing instrument takes considerable amount of useful time and hence must be avoided as far as possible.

Certain principles need to be followed for developing good writing skill for lettering. One must have knowledge of the following parameters in order to master the art of good lettering.

1. shape and proportion of each letter
2. order and direction of the stroke
3. general composition of letters
4. rules for combining letters into words
5. skill of writing the letters in plain and simple style so that the lettering can be done freehand

Single-stroke letters:

The Bureau of Indian Standards (IS: 9609-1990) recommends single stroke lettering for use in engineering drawing. These are the simplest forms of letters and are usually employed in most of the engineering drawings.

The word single stroke should not be misconstrued to mean that the letter should be made in one stroke without lifting the pencil. It actually means that the thickness of the line of the letter should be such as is obtained in one stroke of the pencil. The horizontal lines of letters should be drawn from left to right and vertical or inclined lines from top to bottom.

Single-stroke letters are of two types:

1. Vertical and
2. inclined

Inclined letters lean to the right, the slope being 75^0 with the horizontal. The size of a letter is described by its height. According to the height of letters, they are classified as:

i. Lettering ‘A’
ii. Lettering ‘B’

In lettering ‘A’ type, the height of the capital letter is divided into 14 parts, while in lettering ‘B’ type, it is divided into 10 parts. The height of the letters and numerals for engineering drawing can be selected from 2.5, 3.5, 5, 7, 10, 14 and 20 mm according to the size of the drawing. The ratio of height to width varies but in case of most of the letters it is 6:5. The details of the characteristics of the types of lettering are given in Table 1and Table 2.

Lettering is generally done in capital letters. Different sizes of letters are used for different purposes.

The main titles are generally written in 6 mm to 8 mm size, sub-titles in 3 mm to 6 mm size, while notes, dimension figures etc. in 3 mm to 5 mm size.

The drawing number in the title block is written in numerals of 10 mm to 12 mm size.

Figure 3 shows single-stroke vertical capital letters and figures with approximate proportions.

Single-stroke inclined capital letters and figures are shown in Figure 4. The lower case letters are usually used in architectural drawings. Vertical and inclined lower case alphabets are shown in Figure 5 and Figure 6 respectively. The width of the majority of letters is equal to the height.

All letters should be uniform in shape, slope, size, shade and spacing. The shape and slope of every letter should be uniform throughout a drawing. For maintaining uniformity in size, thin and light guide-lines may first be drawn, and lettering may then be done between them. The shade of every letter must be the same as that of the outlines of the drawings, i.e., intensely black.

Therefore, H or HB grade of pencil is recommended for this purpose. The spacing between two letters should not necessarily be equal. The letters should be so spaced that they do not appear too close together or too much apart.

Judging by the eye the background areas between the letters should be kept approximately equal. The distance between the words must be uniform and at least equal to the height of the letters (as in Figure 7).

Lettering should be so done as can be read from the front with the main title horizontal, i.e., when the drawing is viewed from the bottom edge.

All sub-titles should be placed below but not too close to the respective views. Lettering, except the dimension figures, should be underlined to make them more prominent.

Table 1: Lettering A $\left(d = \frac{h}{14}\right)$

Characteristic	Ratio	Dimensions (mm)						
Letter height Height of capitals h	$\left(\frac{14}{14}\right)h$	2.5	3.5	5	7	10	14	20
Height of lower case letter c	$\left(\frac{10}{14}\right)h$	-	2.5	3.5	5	7	10	14
Space between characters a	$\left(\frac{2}{14}\right)h$	0.35	0.5	0.7	1	1.4	2	2.8
Minimum spacing of base line b	$\left(\frac{20}{14}\right)h$	3.5	5	7	10	14	20	28
Minimum spacing between words e	$\left(\frac{6}{14}\right)h$	1.05	1.5	2.1	3	4.2	6	8.4
Thickness of lines d	$\left(\frac{1}{14}\right)h$	0.18	0.25	0.35	0.5	0.7	1	1.4

Table 2: Lettering B $\left(d = \dfrac{h}{10}\right)$

Characteristic	Ratio	Dimensions (mm)						
Letter height Height of capitals h	$\left(\frac{10}{10}\right)h$	2.5	3.5	5	7	10	14	20
Height of lower case letter c	$\left(\frac{7}{10}\right)h$	-	2.5	3.5	5	7	10	14
Space between characters a	$\left(\frac{2}{10}\right)h$	0.5	0.7	1	1.4	2	2.8	4
Minimum spacing of base line b	$\left(\frac{14}{10}\right)h$	3.5	5	7	10	14	20	28
Minimum spacing between words e	$\left(\frac{6}{10}\right)h$	1.5	2.1	3	4.2	6	8.4	12
Thickness of lines d	$\left(\frac{1}{10}\right)h$	0.25	0.35	0.5	0.7	1	1.4	2

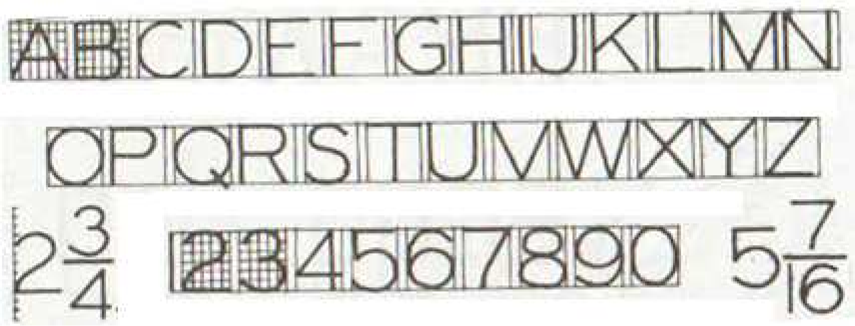


Figure 3

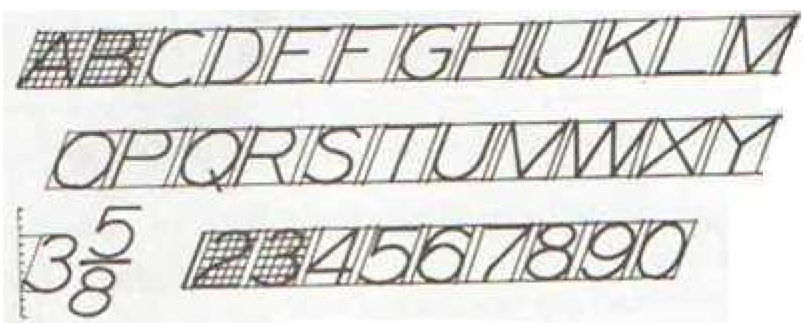


Figure 4

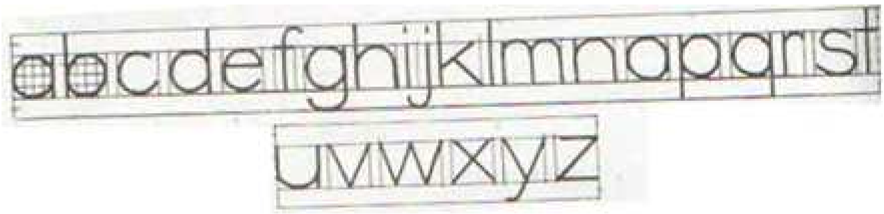


Figure 5

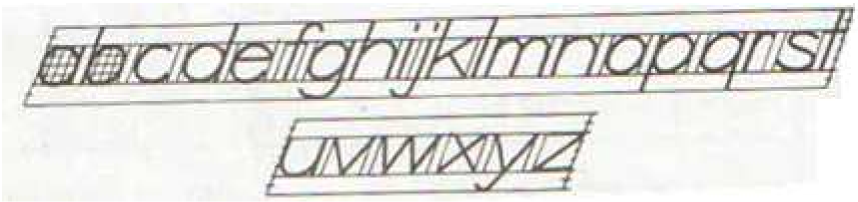


Figure 6

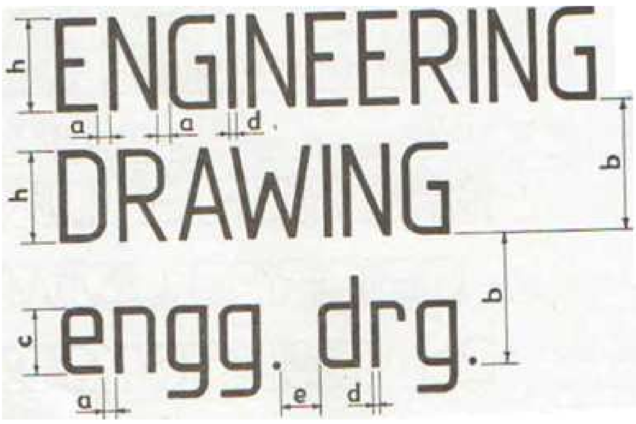


Figure 7

Gothic letters:

Gothic letters are formed by thickening the stems of single-stroke letters. These are mostly used for main titles of ink-drawings. The outlines of the letters are first drawn with the aid of instruments and then filled-in with ink. The thickness of the stem may vary from 1/5th to 1/10th of the height of the letters. Figure 3.9 shows the alphabets and figures in gothic with thickness equal to 1/7 of the height.

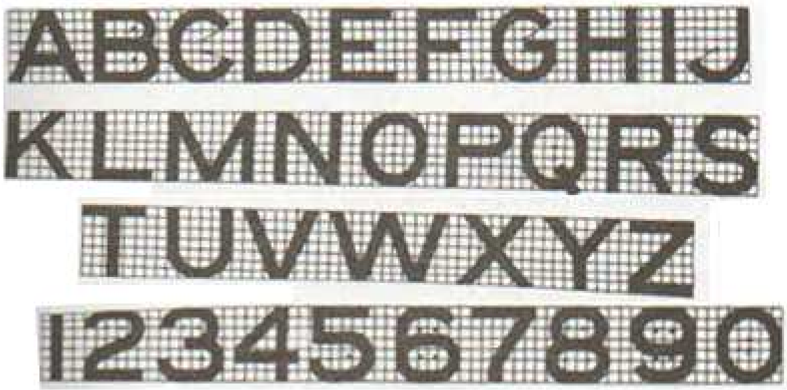


Figure 8

CHAPTER-3

SCALES

What is a scale?

- Drawings of small objects can be drawn on a drawing sheet as the actual size they represent. For example, a paper of size 20cmX 25cm can be shown by a rectangle of size 20cmX25cm on a drawing sheet. Drawings drawn of the same size as the objects are called full-size drawings. The ordinary full size scales are used for the above drawings.
- It is not always possible to draw drawing of an object to its actual size. For instance, drawings of large objects like buildings, large equipments, machines etc. cannot be prepared full size as they would be too large to accommodate on the drawing sheet. Similarly, drawings of small objects like small watches with its parts, small electronic instruments etc. cannot be prepared full size because they would be too small to draw as well as to read.
- *A scale is defined as the ratio of the linear dimensions of element of the object as represented in a drawing to the actual dimensions of the same element of the object*.
- A suitable scale is always chosen to draw the drawings of big as well as small objects in proportionally smaller or larger sizes. Thus, scale can be expressed in the following three ways.
    - Full size scale
    - Reducing scale
    - Increasing scale

Full size scale:

- If actual dimension of an object is shown in the drawing then the scale used is said to be full size scale.
- IT can be represented as 1cm=1cm.

Reducing scale

- If actual dimension of an object is reduced so as to accommodate that object in the drawing to be drawn on the provided drawing sheet, then the scale used is called reducing scale.
- Such scales are used for drawing the large machine parts, buildings, bridges, survey maps, etc.
- Civil Engineers and Architects generally use reducing scale.
- This scale is represented as for example, 1cm=2m. This indicates that the linear dimension of 2m of an actual object is represented by 1cm in the drawing of that object.

Increasing or Enlarging scale

- When the drawings of very small objects are made larger than their actual dimension in the drawing sheet, the scale used is called increasing/enlarging scale.
- Such scales are used for drawing small machine parts, mechanical/electronic instruments, watches, etc.

- Mechanical, Electrical and Electronics Engineers use both reducing as well as enlarging scales as per their requirements.
- This scale is represented as for example, 1cm=2mm. This indicates that the linear dimension of 2mm of an actual object is represented by 1cm in the drawing of that object.

Representative Fraction (R.F.)

- Representative Fraction (R.F.) is the ratio of drawing size of an object to its actual size.
- This is another method of representing scale.
- For reducing scale, the R.F. value is less than unity.
- For enlarging scale, the R.F. value is greater than unity.
- For full size scale, the R.F. value is equal to unity.

Types of scales

- Simple or Plain Scales
- Diagonal Scales
- Vernier Scales

Out of the above three scales Plain Scales and Diagonal Scales are be presented in detail in the following sections.

Plain Scales

- A plain scale is simply a line, which is divided into a suitable number of equal parts.
- The first part is again sub-divided into small parts.
- This is used to represent either two units or a unit and its fraction such as metre and decimeter, kilometre and hectometer, etc.

When a particular scale of our requirement is not available, it becomes necessary to construct a scale.

Construction of Plain Scales

For construction of plain scales following information are required.

- R.F. of scale to be constructed
- Maximum length to be measured
- Divisions to be shown
- If the length of scale and distance to be measured are not mentioned in the problem, then the scale length of 15cm is taken.

Problem 1: *Construct a plain scale to show metres if the R.F is 1:400 and long enough to measure 50metres. Show a distance of 28m on the constructed scale.*

Procedure of Construction of Plain Scale:

- First step is to find out R. F. of the scale to be constructed. In the present problem R.F. is given as 1:400.
- Determination of length of scale(L).

L= R.F x Maximum length to be measured = (1/400)x 50x 100cm =12.5cm

- Draw horizontal line of length 12.5cm (L)
- Then draw a rectangle of size 12.5cm x 0.5cm on the above horizontal line. *Width of scale is usually taken as 5mm*
- As the total length to be measured is 50m, divide the above rectangle into 5 equal divisions, each division representing 10m.
- Mark 0 at the end of first division.
- From 0, number 10, 20, 30 and 40 at the end of each main division as shown in Fig.1.
- Sub-divide the first main division into 10 sub-divisions to represent meters using any of geometrical construction method.
- Number the subdivisions as shown in Fig.1
- Write the names of main unit and sub-unit below the scale with R.F. below the scale as shown.
- Indicate on the scale a distance of 28m (=2 main divisions to the right side of 0 +8 sub-divisions to the left of 0.

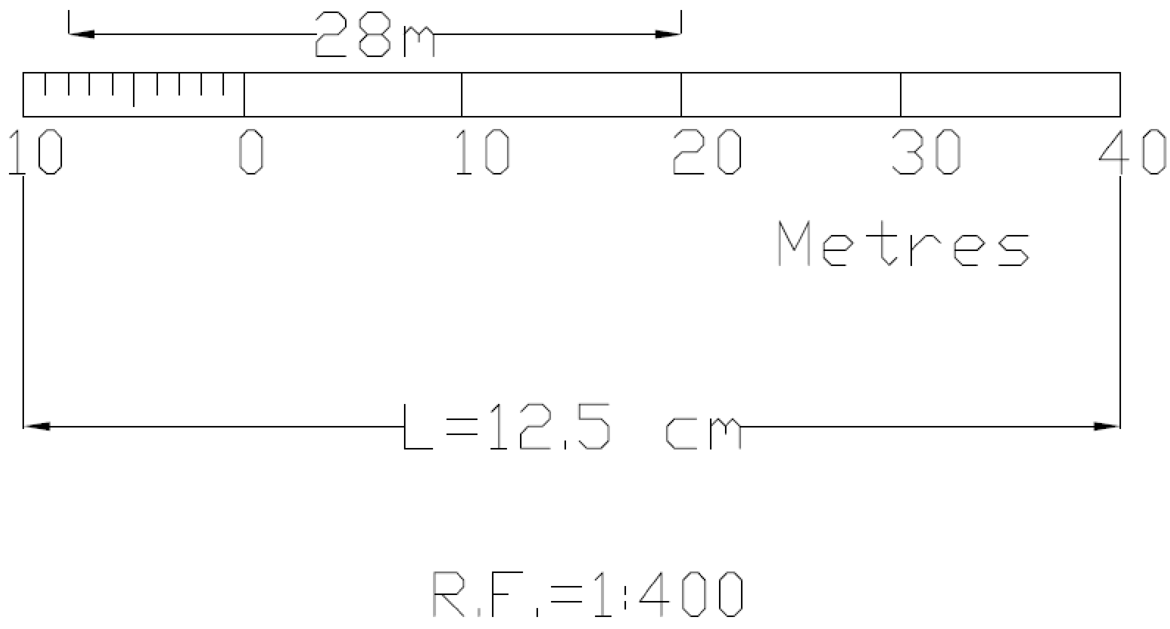


Fig. 1 PLAIN SCALE

Diagonal Scales

Diagonal scales are used to represent either three consecutive units (i.e. m, dcm, cm) or to read to the accuracy correct to two decimals.

Principle of diagonal scale

- It consists of a line divided into required number of equal parts.
- The first part is sub-divided into small parts by diagonals.

- In Fig.2, let AB be the small length (sub-division) to be further divided into 10 equal parts.
- Draw verticals at A and B. Divide AD into 10 equal divisions of any convenient length (say 5cm) and complete the rectangle ABCD.
- Join the diagonal AC. draw horizontal lines through the division points to meet c at 1’, 2’, 3’, …,9’.
- Let consider similar triangle ADC and A66’.
  66’/DC=AB/AD;
  But, A6=(6/10)AD;
  Thus, (66’/DC) =6/10; 66’=(6/10)DC=0.6DC=0.8AB.
  Similarly it can be shown that the horizontal lengths 11’, 22’, 33’ etc. are equal to 0.1AB, 0.2AB, 0.3AB etc. respectively. This principle is used in constructing the diagonal scale.

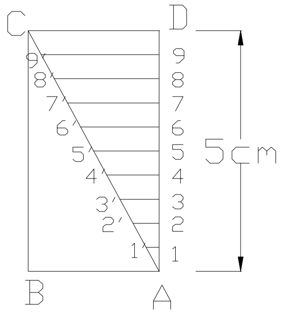


Fig.2

Problem 2: *On a building plan a line 10cm long represents a distance of 5m. Construct a diagonal scale for the plan to read up to 6m, showing metres, decimetres and centimetres. Indicate the lengths 3.35m and 5.78m on the constructed scale.*

Procedure of Construction of Diagonal Scale:

- R.F. = 10cm/5x100cm = 1/50
- Length of scale, L= (1/50)x 6 x 100 cm =12 cm
- Draw a rectangle ABCD of size 12cm x 5cm.
- Max/ min = (6 x100 cm)/1cm =600 =6 x 10 x 10.
- Divide AB into 6 main divisions, each representing 1m. Mark 0, 1, 2, 3, 4, 5 and draw the vertical lines through each point.
- Sub-divide the first main division into 10 equal sub-divisions each representing decimeter. Mark 0 to 10 towards the left of 0.
- Divide AD into 10 equal parts and draw horizontal lines from each division on AD.

- Join D to the first sub-division from A on the main scale AB. Thus, first diagonal is drawn.
- Similarly remaining 9 diagonals parallel to the first diagonal are drawn.
- 3.35m and 5.78m are shown on the constructed diagonal scale (Fig. 3).

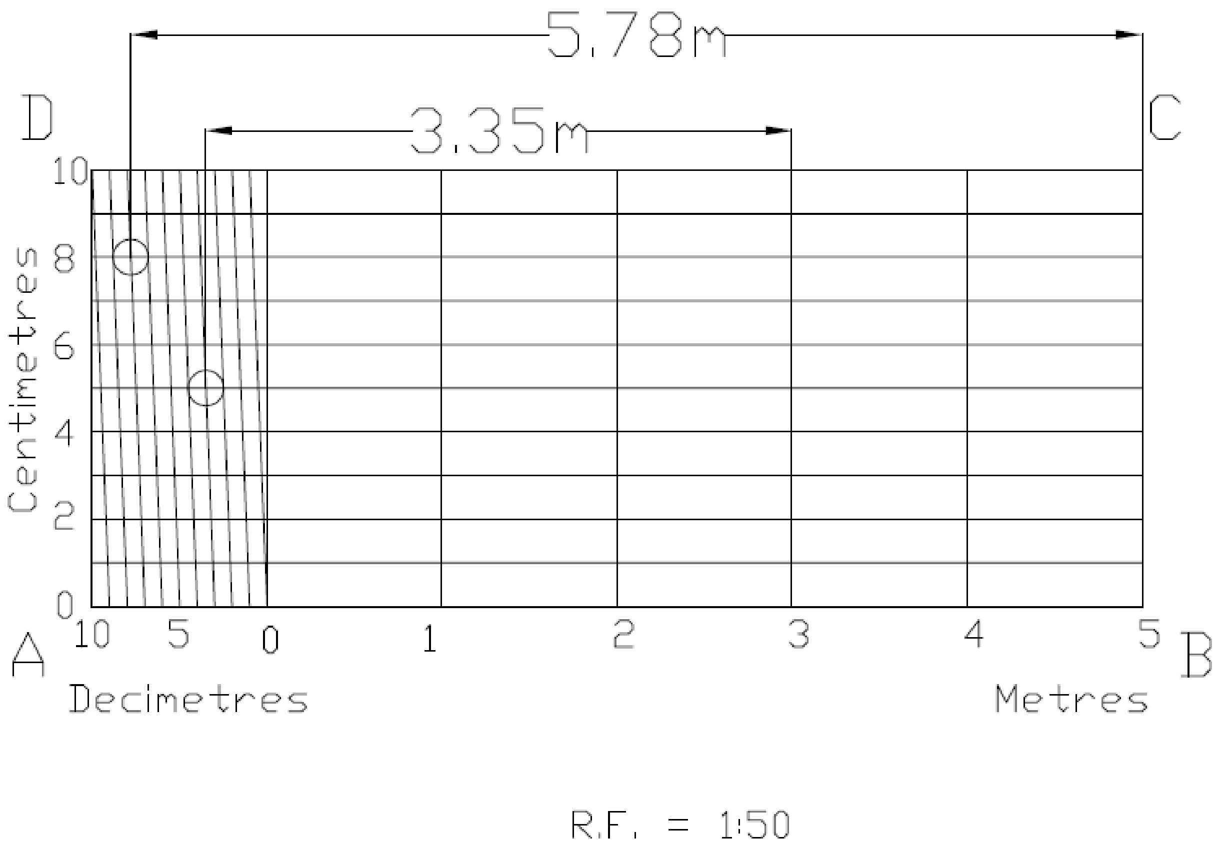


Fig. 3 DIAGONAL SCALE

EXERCISES

1. Construct a plain scale with R.F. of 1: 4 to show centimeters and long enough to measure upto 5 decimetres.
2. Construct a plain scale of R.F. 1:50,000 to show kilometers and hectometers and long enough to measure upto 7 kilometres. Indicate a distance of 56 hectometres on your scale.
3. Construct a diagonal scale of R.F, = 1 : 32,00,000 to show kilometers and long enough to measure upto 400km. Show distances of 238 km and 375km on your scale.
4. Construct a diagonal scale of R. F. 1 : 4000 to show metres and long enough to measure upto 500m. Show a distance of 376m on your scale.

   The area of afield is 50,000 sqm. The length and breadth of the field on the map is 10 cm and 8 cm respectively. Construct a diagonal scale which can read upto one metre. Mark the length of 244m on the scale. What is the R.F. of the scale?

CHAPTER-4

CONIC SECTIONS

OBJECTIVE:

The conic sections (or conics) - the ellipse, the parabola and the hyperbola - play an important role both in mathematics and in the application of mathematics to engineering. The main objective of this chapter is, therefore, to deal with the construction of various types of plane curves such as ellipse, parabola and hyperbola, etc which are otherwise known as conic sections. These curves are very often used in engineering practices. Many engineering structures such as arches, bridges, dams, monuments, cooling towers, water channels, chimneys, roofs of stadiums, etc. involve geometries of conic sections. It is therefore very much necessary to study the nature of these curves together with some of their geometric properties and explain some of the convenient methods for construction of these curves.

CONIC SECTION:

Conics (conic sections) are essentially a class of curves which are obtained when a double cone is intersected by a plane at different angles relative to the axis of the double cone. There are three main types of conics: the ellipse, the parabola and the hyperbola. From the ellipse we obtain the circle as a special case, and from the hyperbola we obtain the rectangular hyperbola as a special case. The circle is a special case of the ellipse, and is of sufficient interest in its own right that it is sometimes called the fourth type of conic section.

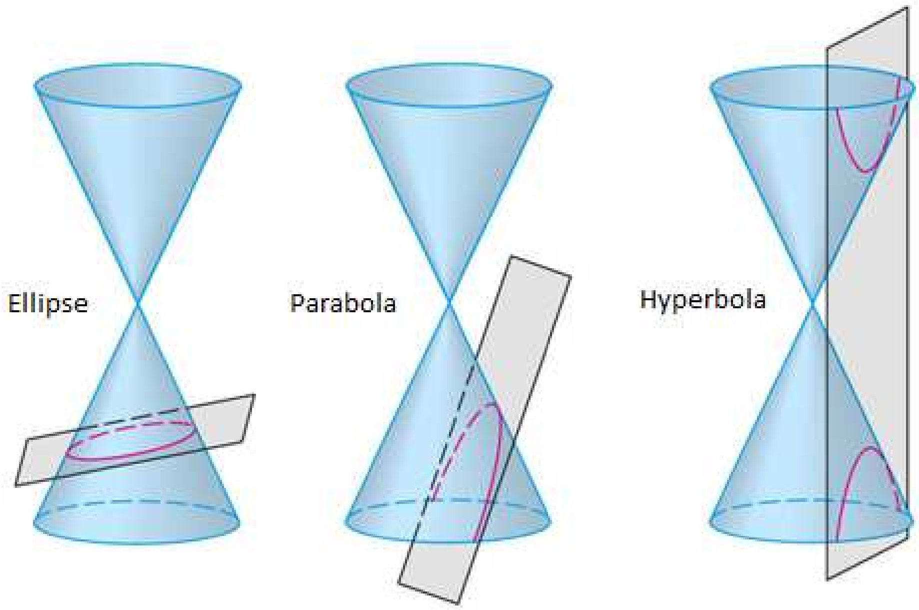


Figure 1

1. Ellipse

The section plane obtained by the intersection of a cutting plane, inclined to the axis of the cone and cutting all the generators, is called an ellipse. The angle of inclination of the cutting plane with the axis of the cone is more than that of the generator with the axis. An ellipse is a closed curve.

An imaginary line joining the apex to the centre of the base of the cone is known as the axis of the cone. The top point of the cone is called the apex.

2. Parabola

The section plane obtained by the intersection of a cutting plane, inclined to the axis of the cone and parallel to one of the generators, is called a parabola.

3. Hyperbola

The section plane obtained by the intersection of a cutting plane, inclined to the axis of the cone at an angle less than the inclination of the generator with the axis (semi-vertical angle, is called a hyperbola. In this case the cutting plane cuts the cone on one side of the axis.

4. Circle

The section plane obtained by the intersection of a cutting plane, parallel to the base of the cone, is called a circle. Circle is a special is the special case of the ellipse and is sometimes referred to as fourth type of conic section.

In analytic geometry, a conic may be defined as a plane algebraic curve of degree 2. There are a number of other geometric definitions possible. To have one such geometric definition, one has to know the term called *locus*.

Locus

The path traced out by a point when it moves in the space, under given conditions or in accordance with a definite law, is known as a locus of that point (loci in the plural).

Geometrical definition of conic/ conic section as a plane of *loci*

A conic section or conic is defined as the locus of a point moving in a plane in such a way that the ratio of its distances from a fixed point and a fixed straight line is always constant. The fixed point is called the *focus* and the fixed line is called the *directrix*.

The ratio $\dfrac{disance\ of\ the\ point\ from\ the\ focus}{distance\ of\ the\ point\ from\ the\, directrix}$ is called eccentricity and is denoted by *e*.

For ellipse, this eccentricity is always less than 1 ($e < 1$). It is equal to 1 ($e = 1$) for parabola and greater than 1 ($e > 1$) for hyperbola.

The line passing through the focus and perpendicular to the directrix is called the axis. The point at which the conic cuts its axis is called the *vertex*.

Ellipse

Ellipse is the locus of a point moving in a plane in such a way that ratio of its distances from a fixed point (focus) and a fixed straight line (directrix) is constant and is always less than one. Ellipse is a closed curve having two foci and two directices.

Parabola

Parabola is locus of a point moving in a plane in such a way that the ratio of its distances from a fixed point and a fixed straight line is constant and is equal to one. Parabola is an open curve of conic section.

Hyperbola

Hyperbola is locus of a point moving in a plane in such a way that the ratio of its distances from a fixed point and a fixed straight line is constant and is always greater than one. Hyperbola is an open curve of conic section.

PROPERTIES OF CONIC SECTIONS

<u>*Properties of ellipse*</u>

The equation of an ellipse is $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$ where *a* = half the major axis. *B* = half the minor axis. The origin is the centre of the ellipse. The vertices are at a distance *a* from the centre *C* on both sides of the x axis. For different values of *x* like $0, \pm 1, \pm 2$ etc. The corresponding values of $y = \pm b\sqrt{1}, \pm b\sqrt{1-\frac{1}{a^2}}, \pm b\sqrt{1-\frac{4}{a^2}}$ ....

For any particular value of *x*, there are two equal and opposite values of *y*. The curve therefore is symmetric about the x-axis. For every +ve or –ve value of *x*, the values of *y* are identical and hence the curve is symmetrical about the y-axix.

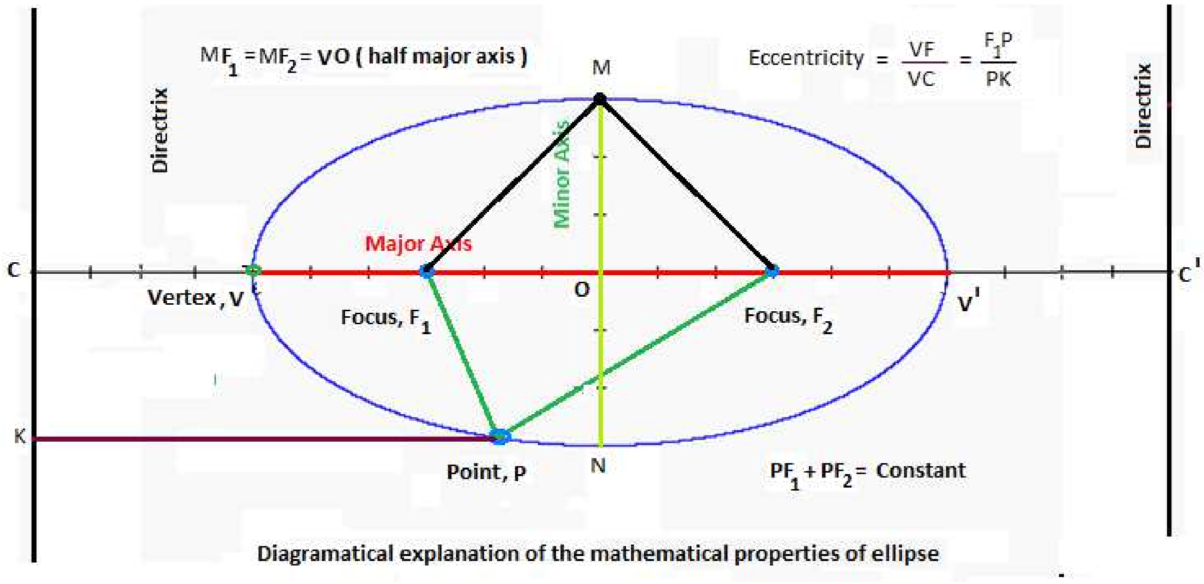
Properties of ellipse

1. Ellipse is the locus whose sum of distances from two fixed points is constant.

2. The length of the line segment from the end of a minor axis to a focus is the same as half the length of a major axis.

3. A light ray originating from one focus will pass through the opposite focus after reflecting off of the ellipse.

4. At all points on the ellipse, the sum of distances from the foci is 2a (twice the semi-major axis. This is another equation for the ellipse.



From each point on the curve, the distance to the focus equals the distance to the "directrix

Every ray coming straight down is reflected to the focus

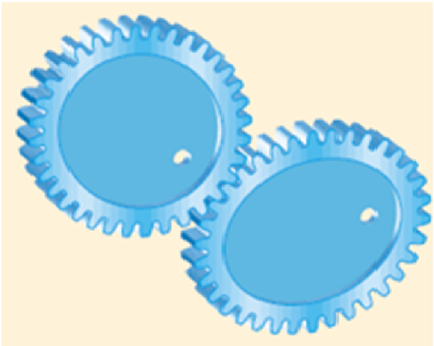
Applications of ellipse

There are many incident and uses of elliptical forms: orbits of satellites, planets, and comets; shapes of galaxies; gears and cams; some airplane wings, boat keels, and rudders; tabletops; public fountains; and domes in buildings are a few examples (see Fig. 2).

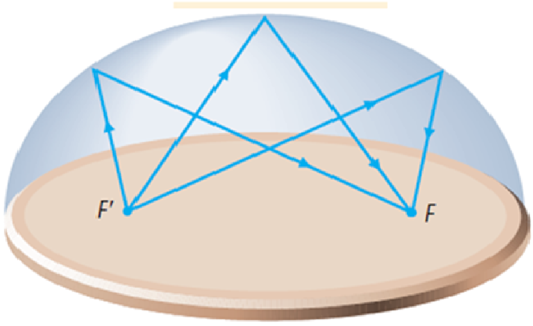
Figure 2(a) shows a pair of elliptical gears with pivot points at foci. Such gears transfer constant rotational speed to variable rotational speed, and vice versa. Figure 2(b) shows an elliptical dome. An interesting property of such a dome is that a sound or light source at one focus will reflect off the dome and pass through the other focus. The "whispering gallery" of the United States Senate is an ellipse. If you stand atone focus and whisper (speak quietly), you can be heard at the other focus (and nowhere else).Your voice is reflected off the walls to the other focus-following the path of the string.

Structural components with elliptical configuration have wider application in aerospace engineering and naval architecture. Figure 2(c) shows an aeroplane with its trailing edge, and wings and tails of elliptical shape. Of all possible wing shapes, it has been determined that the one with the least drag along the trailing edge is an ellipse. Use of elliptical reflectors and ultrasound to break up kidney stones is a fairly recent application in medicine. Shown in Figure 2(d) is a device called lithotripter which is used to generate intense sound waves that break up the stone from outside the body, thus avoiding surgery. The reflecting property of the ellipse is used to design and correctly position the lithotripter to ensure that the waves do not damage other parts of the body.

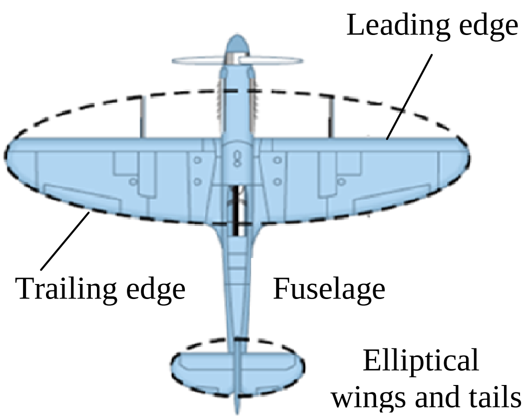
High-performance racing sailboats, shown in Figure 3, use elliptical keels, rudders, and main sails for the same reason as in the case of aeroplane wings.



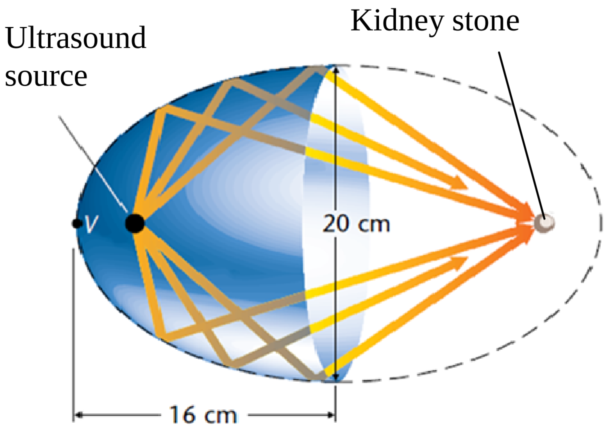
(a) Elliptical



(b) Elliptical

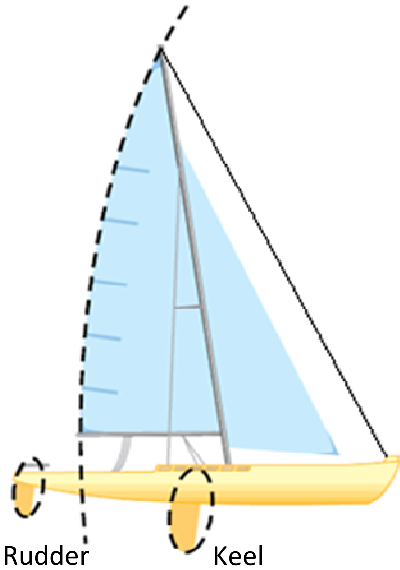


(c) Wing and trailing edge

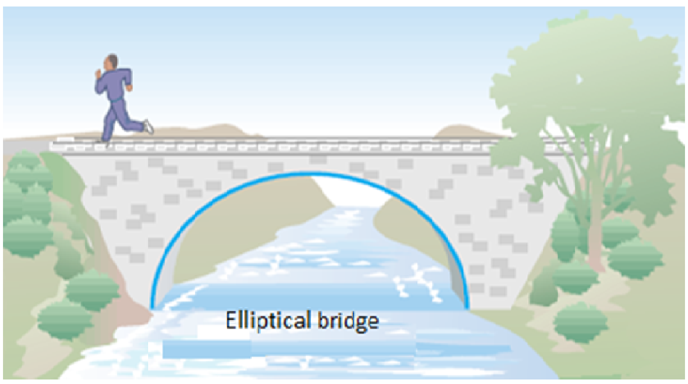


(d) Lithotripter

Figure 2



(a) Racing sail-boats



(b) Elliptical bridge

Figure 3

<u>Methods of construction of ellipse</u>

There are a number of methods available for construction of ellipse. The type of method to be used for construction of ellipse depends on the specific parameters of an ellipse. Some of the methods are mentioned as follows.

1. Eccentricity method
2. Concentric circle method
3. Arc of the circle method
4. Loop of thread method
5. Oblong method/Rectangle method
6. Trammel method
7. Four centres approximate method
8. Parallelogram method
9. Circumscribing parallelogram method

Of the above mentioned methods, the first three methods are included in the syllabus and need special attention so far as their constructional procedure is concerned.

1. Eccentricity method

This method is used when the eccentricity and the distance of the focus from the directrix are given. In the present case let us assume the eccentricity, e = 2/3

1. Draw a vertical line DD' as the directrix.
2. Draw CC' as the axis of the ellipse from any suitable point C on the directrix such that CC' is perpendicular to the directrix.
3. Mark a focus F on the axis such that CF is equal to the distance between the directrix and the focus.
4. Divide CF into 5 equal parts and mark the vertex on the 3rd division point from C. Thus $eccentricity = \frac{VF}{VC} = 2/3$
5. Draw a perpendicular VE equal to VF. Now draw a line joining C and E and prolong it in the direction of CE. Thus , in triangle, CVE, $\frac{VE}{VC} = \frac{VF}{VC} = \frac{2}{3}$ $\quad$ (since $VE = VF$)
6. Mark a point 1 on the axis and draw a perpendicular through it so as to meet prolonged CE at $1'$.
7. With F as centre and radius equal to $1-1'$, draw arcs to intersect the perpendicular through 1 at P_1 and P_1'.

The points P_1 and P_1' lie on the required ellipse because the ratio P_1 from DD' is equal to C1, $P_1F = 1-1'$ and $\frac{1-1'}{C1} = \frac{VF}{VC} = \frac{2}{3}$. Similarly, mark points 2, 3 etc. on the axis and obtain points P_2 and P_2', P_3 and P_3' etc.

8. Draw the ellipse through these points. The ellipse, so obtained is a closed curve with two foci and two directrices.

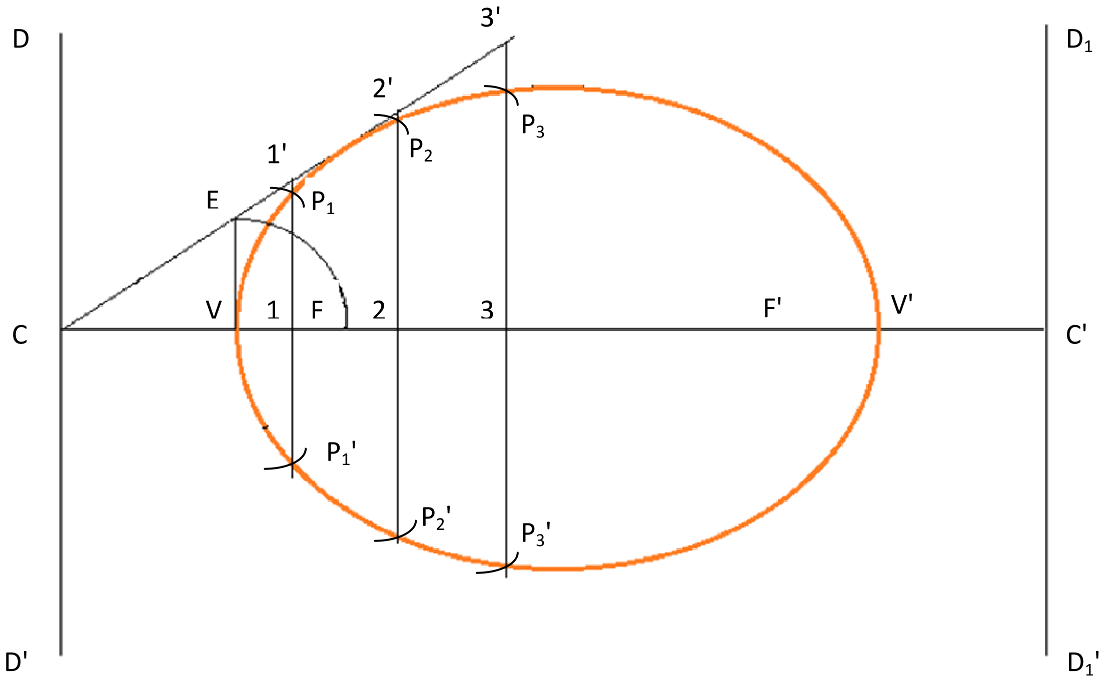


Figure 4

2. Concentric circle method

This method is used when the lengths of major and minor axes of an ellipse are given.

Procedure of construction

a. Draw the major axis and minor axes as AB and CD respectively so as to intersect each other at right angles at O as shown in the figure.
b. With centre O and AB and CD as diameters draw two circles.
c. Divide the circle described on the major axis (major-axis-circle) into a number of equal divisions, say 12 and mark 1,2 etc as shown.

d. Draw lines joining these points with the centre O and cutting the circle described on the minor axis (manor-axis-circle) at points $1', 2'$ etc.

e. Through point 1 on the major-axis-circle, draw a line parallel to CD, the minor axis.

f. Through point $1'$ on the minor-axis-circle, draw a line parallel to AB, the major axis.

g. Mark the point of intersection of the above two parallel lines as P_1. The point P_1, thus obtained, is a point on the required ellipse.

h. Repeat the construction through all the points and get more points.

i. Draw a smooth curve through all these points. The curve, so obtained, is the required ellipse.

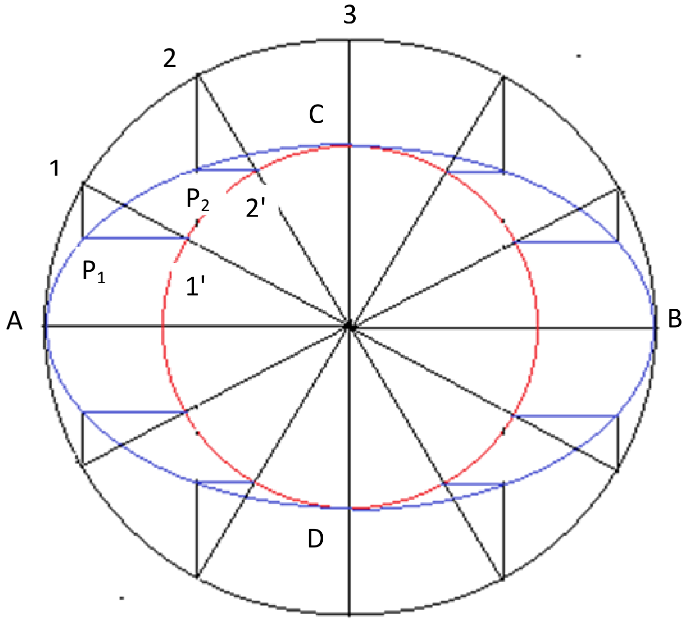


Figure 5

3. Arc of circle method

This method is also used when the lengths of major and minor axes of an ellipse are given.

a. Draw the major axis and minor axes as AB and CD respectively so as to intersect each other at right angles at O as shown in the figure.

b. Draw two arcs with C as centre and radius equal to AO (semi-major axis = half of AB) so as to cut major axis AB at F_1 and F_2. F_1 and F_2 are the foci of the ellipse.

c. Mark a number of points 1, 2, 3 etc. on AB.

d. With F_1 and F_2 as centres and A1 as radius, draw arcs on both sides of AB.

e. With same centres and radius equal to B1, draw arcs intersecting the previous arcs at four points marked as P_1.

f. Similar points are obtained with radii A2 and B2; and A3 and B3 etc.

g. Draw a smooth curve through all these points. The curve, so obtained, is the required ellipse.

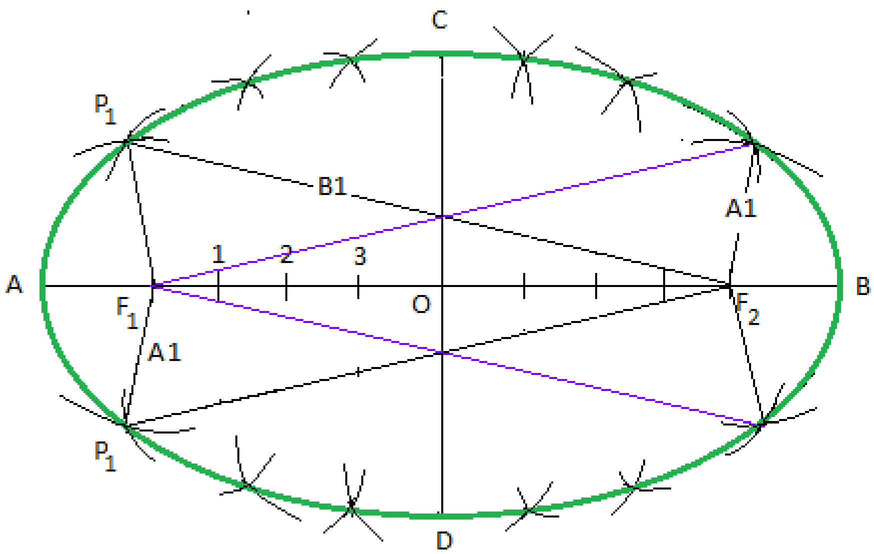


Figure 6

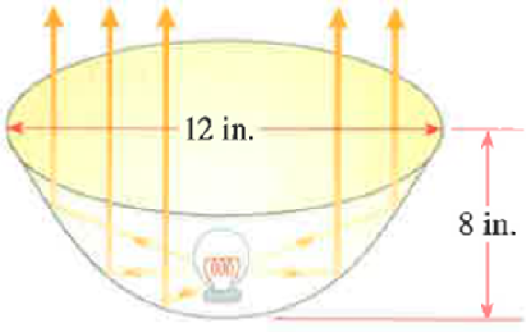
Properties of parabola

Remind students that a defining property for a parabola is the set of points P satisfying FP = PP'.

Application of parabola

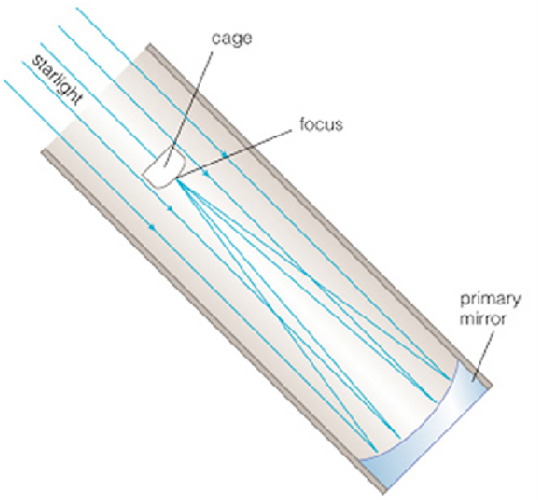
Parabolas have an important property that makes them useful as reflectors for lamps and telescopes. Light from a source placed at the focus of a surface of parabolic cross section will be reflected in such a way that it travels parallel to the axis of the parabola. Thus a parabolic mirror reflects light into a beam of parallel rays. Conversely, light approaching the reflector in rays parallel to its axis of symmetry is concentrated to the focus. This reflection property is used in the construction of reflecting telescopes.

In parabolic microphones, a parabolic reflector that reflects sound, but not necessarily electromagnetic radiation, is used to focus sound onto a microphone, giving it highly directional performance.
Unlike an inelastic chain, a freely hanging spring of zero unstressed length takes the shape of a parabola. Suspension-bridge cables are, ideally, purely in tension, without having to carry other, e.g. bending, forces. Similarly, the structures of parabolic arches are purely in compression.



(a) Parabolic reflector

(b) Satellite dish



(c) Telescope

(d) Solar cooker with parabolic reflector

Figure 7

(a) An array of parabolic troughs to collect solar energy (b) A parabolic antenna

(c) A parabolic arch bridge (The parabolic arch is in compression)

Figure 8

<u>Methods of construction of parabola</u>

There are a number of methods available for construction of parabola. The type of method to be used for construction of parabola depends on the specific parameters of a parabola. Some of the methods are mentioned as follows.

1. Eccentricity method
2. Rectangle method
3. Tangent method
4. Measured abscissa method
5. Parallelogram method

Of the above mentioned methods, the first three methods are included in the syllabus and need special attention so far as their constructional procedure is concerned.

1. Eccentricity method

This method is used when the distance between the directrix and the focus is given.

a. Draw a vertical line DD' as the directrix.

b. Draw CC' as the axis of the parabola from any suitable point C on the directrix such that CC' is perpendicular to the directrix.

c. Mark focus F on the axis CC'.

d. Bisect CF to get the vertex V. $\left(since,\ eccentricity = \dfrac{VF}{VC} = 1 \right)$

e. Mark a number of points 1, 2, 3 etc. on the axis and through these points draw perpendiculars to the axis.

f. With F as centre and C1, C2, C3 etc. as radii, draw arcs so as to cut the perpendiculars through relevant points (perpendiculars through 1, 2, 3 etc.) at P_1 and P_1', P_1 and P_2', and P_1 and P_3' etc.

g. Draw a smooth curve through these points. The curve thus obtained is the required parabola.

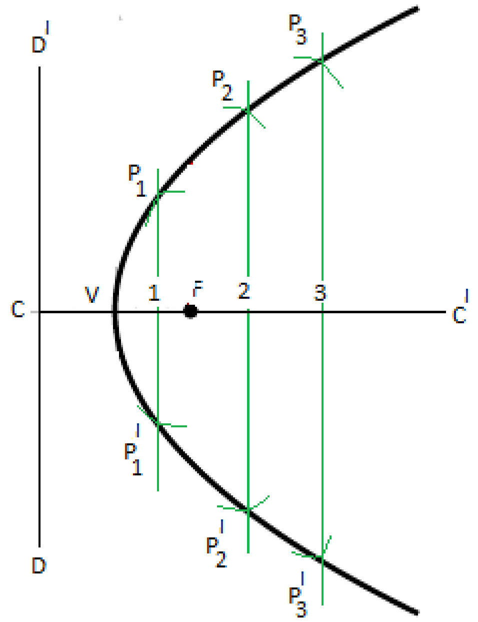


Figure 8

2. Rectangle method

This method is used when the base and the axis are given.

a. Draw a line AB as the base and mark the midpoint M on it.

b. Through M, draw the axis MN at right angles to AB.

c. Draw a rectangle ABCD with side BC equal to MN.

d. Divide AM and AD into same number of equal parts and name them as shown .Draw lines joining N with 1, 2 and 3.

e. Through 1', 2' and 3', draw perpendiculars to AB so as to intersect F1, F2 and F3 at points P_1, P_2 and P_3 respectively.

f. Draw a smooth curve through these points. The curve thus obtained is the required parabola.

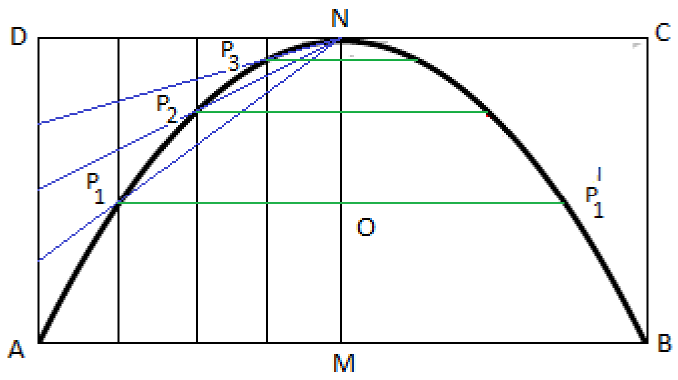


Figure 8

3. Tangent method

This method is also used when the base and the axis are given.

a. Draw a line AB as the base and mark the midpoint M on it.

b. Through M, draw the axis MN at right angles to AB.

c. Produce MN to O so that MN = NO.

d. Join O with A and B. Divide lines OA and OB into the same number of equal parts (say 7 or eight). More the number of parts better would be the parabola.

e. Mark the division points as shown in the figure.

f. Draw lines joining 11', 22', 33' and so on.

g. Draw a smooth curve starting from A and tangential to these lines. The curve so obtained is the required parabola.

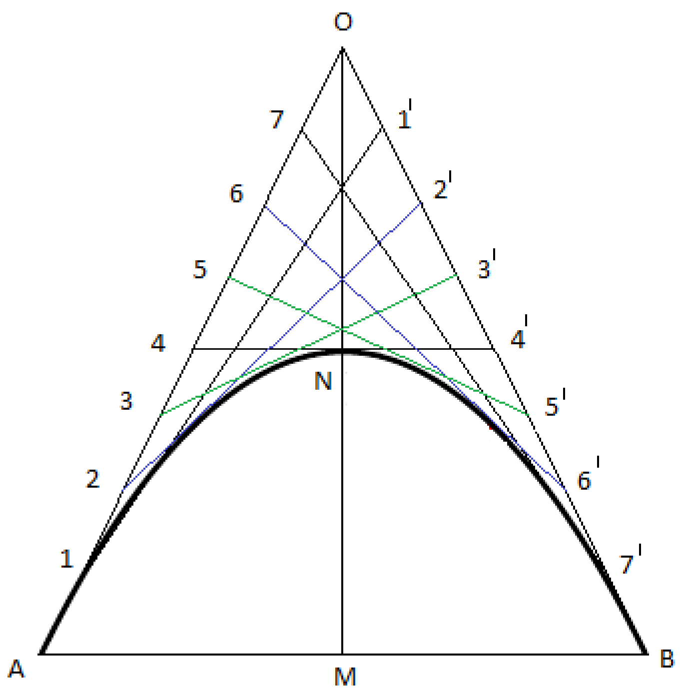


Figure 9

Methods of construction of hyperbola

1. Eccentricity method

This method is used when the distance of the focus from the directrix and the eccentricity are given. In the present case let us assume the eccentricity, e = 3/2

a. Draw a vertical line DD' as the directrix.

b. Draw CC' as the axis of the hyperbola from any suitable point C on the directrix such that CC' is perpendicular to the directrix.

c. Mark focus F on the axis CC'.

d. Divide CF into 5 equal parts and mark the vertex as V on the 2nd division point from C. Thus $eccentricity = \frac{\mathrm{VF}}{\mathrm{VC}} = 3/2$

e. Draw a perpendicular VE equal to VF. Now draw a line joining C and E and prolong it in the direction of CE. Thus , in triangle, CVE, $\frac{\mathrm{VE}}{\mathrm{VC}} = \frac{\mathrm{VF}}{\mathrm{VC}} = \frac{3}{2}$ (since $\mathrm{VE} = \mathrm{VF}$)

f. Mark a point 1 on the axis and draw a perpendicular through it so as to meet prolonged CE at $1'$.

g. With F as centre and radius equal to $1-1'$, draw arcs to intersect the perpendicular through 1 at P_1 and P_1'.

The points P_1 and P_1' lie on the required ellipse because the ratio P_1 from DD' is equal to C1, $P_1F = 1-1'$ and $\frac{1-1'}{C1} = \frac{VF}{VC} = \frac{3}{2}$. Similarly, mark points 2, 3 etc. on the axis and obtain points P_2 and P_2', P_3 and P_3' etc.

h. Draw the hyperbola through these points. The hyperbola so obtained is an open curve with a focus and a directrix.

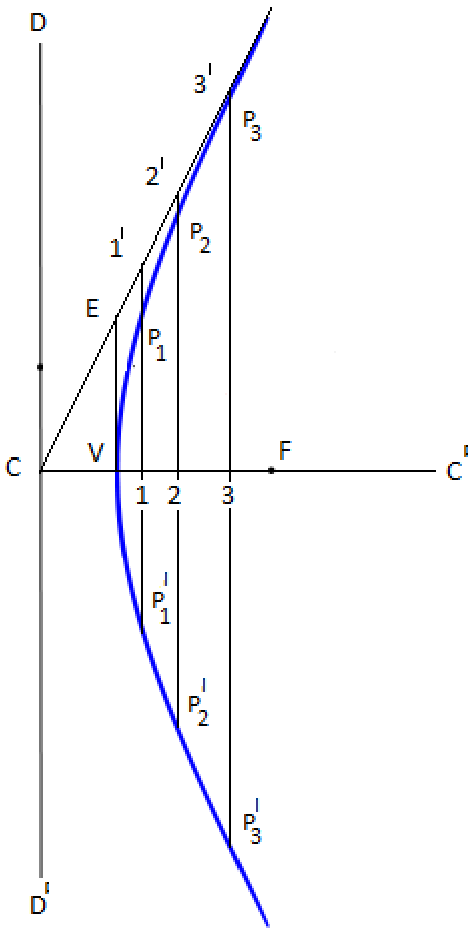


Figure 10

Examples on ellipse:

Problem 1

Construct an ellipse when the distance of the focus from the directrix is equal to 60 mm and eccentricity is 2/3.

Problem 2

A point moves in such a way its distance from a fixed line is always 1.5 times the distance from a fixed point 50 mm away from the fixed line. Draw the locus of the point and name the curve.

Problem 3

Draw an ellipse of major axis 150 mm if the ratio of the major axis to the minor axis is 3:2. Use concentric circle method.

Problem 4

A particle *P* moves such that the sum of its distances from two fixed points, 90 mm apart, remains constant. When *P* is at equal distance from the fixed points its distance from each one of them is 75 mm. Draw the path traced out by the particle. Hint: use arc of the circle method.

Solution:

a. Draw the major axis $AB = PF_1 + PF_2 = 2 \times 75 = 150\,mm$. P, is the position of particle at any instant.

b. Draw perpendicular bisector to AB at O.

c. Locate the foci at F_1 and F_2 45 mm each from the centre.

d. With F_1 as centre and PF_1 = 75 mm as radius, draw an arc to intersect the bisector through O on both sides of AB to get C and D.

e. Mark a number of points 1, 2, 3 . . . . etc. on the major axis AB between F_1 and F_2. Equidistant points from O make the construction convenient.

f. With F_1 and F_2 as centres and A1 as radius, draw arcs on both sides of AB.

g. With same centres and radius equal to B1, draw arcs intersecting the previous arcs at four points marked as P_1.

h. Similar points are obtained with radii A2 and B2; and A3 and B3 etc.

i. Draw a smooth curve through all these points. The curve, so obtained, is the required ellipse.

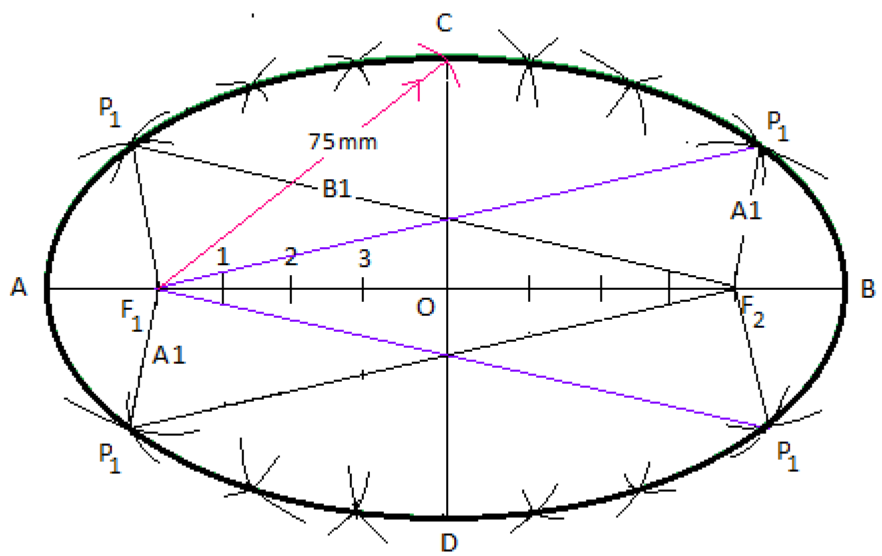


Figure 11

Examples on parabola:

Problem 1

Construct a parabola when the distance between the directrix and the focus is 50 mm.

Problem 2

Draw a parabola by tangent method, given the base and axis 60 mm and 30 mm respectively.

Problem 3

A cricket ball thrown up in the air reaches a maximum height of 10 m and falls on the ground at a distance of 30 m from the point of projection. Trace the path of the ball, assuming the path to be parabolic.

Examples on hyperbola:

Problem 1

Construct a hyperbola if the distance between the directrix and the focus is 25 mm and the eccentricity is 5;2.

Problem 2

Construct a hyperbola, given the distance between the focus and the directrix is 65 mm and the eccentricity is 3:2.

Ceiling of Statutory hall in US capitol

Roof of Skydome in Toronto

Attic in La Pedrera, Barcelona, Spain

McDonnel Planetarium, St. Louis, MO

CHAPTER-5

ORTHOGRAPHIC PROJECTION

PROJECTION OF STRAIGHT LINES

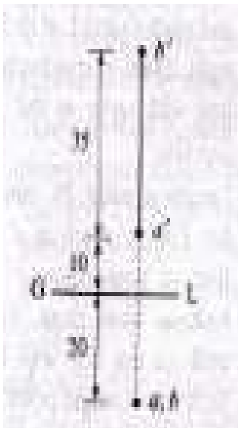
Lines in space are three types considering their position with respect to reference planes i.e. Horizontal Plane (HP) and Vertical Plane (VP):

1. Line parallel to one and perpendicular to other reference plane
2. Line parallel to both reference plane
3. Line parallel to one and inclined to other reference plane
4. Line inclined to both reference planes

Case-1 Line parallel to one and perpendicular to other reference plane

Example: 1

Draw the projection of a straight line AB of length 35mm, which is perpendicular to HP and parallel to VP. Point A is 10mm above HP and 20mm in front of VP.



Steps:

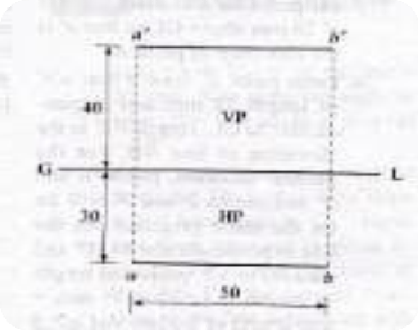
a. Draw the horizontal XY to represent reference line.
b. Locate a point 20mm below XY and mark as a. As the line is perpendicular to HP looking from the top both ends of the line will be projected as a single point. Hence the point b will coincide with a.
c. Draw a vertical projector through a and mark a point a' at 10 mm above the reference line to mark elevation of A.
d. Draw a line a'b' of length 35mm on the vertical projector and mark b' as the elevation of point B
   As the line is parallel to VP projected length in elevation (a'b') = 35mm= True length of the line.

*In case of line perpendicular to VP and parallel to HP the elevation of line a'b' will be a single line and the top view will be equal to true length of line drawn through the vertical projector through a' and drawn below reference line.

Case-2 Line parallel to both reference planes

Example: 2

Draw the projection of a straight line AB of length 50mm, which is parallel to both HP and VP. Point A is 40mm



above HP and 30mm in front of VP.

Steps:

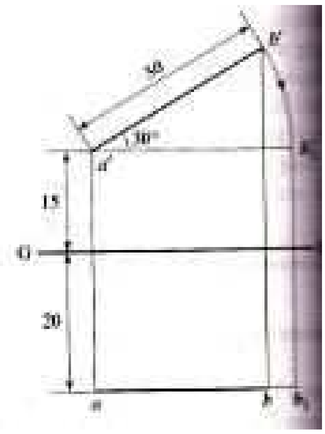
a. Draw the horizontal reference line XY.
b. Locate a point a 30mm below XY to represent top view of point A. Draw a line ab through a of 50mm long parallel to XY. Hence ab is the plan or top view of the line AB.
c. Draw a vertical projector through a and mark a point a' at 40mm above XY. Draw a line a'b' through a' of 50mm long parallel to XY. Hence a'b' is the elevation or front view of the line AB.
d. As the line is parallel to both HP and VP the projected length in top view (ab) =projected length in front view (a'b') = 50mm=true length of the line.

Case-3: Line parallel to one and inclined to other reference plane

Since the line is parallel to one reference plane the projection length on that plane will be equal to the true length of line and that projection will be drawn inclined to other plane. The projection length on the plane to which it is inclined will be of shorter length.

Example: 3

Draw the projection of a straight line AB of length 30mm, which is parallel to VP and inclined at 30^0 to HP. Point A is 15mm above HP and 20mm in front of VP.

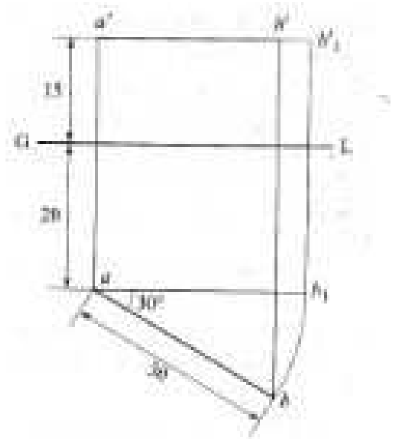


Steps:

a. Draw the horizontal reference line XY.
b. Locate a point a’ 15mm above XY to represent front view of point A.
c. Through point a’ draw a vertical projector and mark point a 20 mm below XY to represent top view of A.
d. Draw arbitrary horizontal line through a’ parallel to XY. Through a’ draw a line a’b’ inclined at 30^0 with horizontal line such that a’b’ = 30mm =True length of line, as the line is parallel to VP. The angle of elevation is = angle of the line with HP(Θ)=30^0
e. From point b’ draw the vertical projector and through a draw a horizontal line parallel to XY. These two lines intersect at point b. hence ab is the top view of the line AB. As the line is inclined to HP the projected length is < true length of the line.

Example: 4

Draw the projection of a straight line AB of length 30mm, which is parallel to HP and inclined at 30^0 to VP. Point A is 15mm above HP and 20mm in front of VP.



Steps:

a. Draw the horizontal reference line XY.
b. Locate a point a’ 15mm above XY to represent front view of point A.
c. Through point a’ draw a vertical projector and mark point a 20 mm below XY to represent top view of A.
d. Draw arbitrary horizontal line through a parallel to XY. Through a draw a line ab inclined at 30^0 with horizontal line such that ab = 30mm =True length of line, as the line is parallel to HP. The angle of elevation is = angle of the line with VP(Ø)=30^0
e. From point b draw the vertical projector and through a’ draw a horizontal line parallel to XY. These two lines intersect at point b’. Hence a’b’ is the front view of the line AB. As the line is inclined to VP the projected length (front view) is < true length of the line.

Case-4: Line inclined to both reference planes

The projection of a straight line AB inclined to both HP and VP can be drawn with the following steps;

1. Assuming the line inclined to HP and parallel to VP draw its apparent front view a’b_1' taking its true length and true angle of inclination (Θ) with HP. Draw the locus of point B in VP by drawing a horizontal line through b_1'.

2. Assuming the line inclined to VP and parallel to HP draw its apparent top view ab_2 taking its true length and true angle of inclination (Ø) with VP. Draw the locus of point B in HP by drawing a horizontal line through b_2.

To draw the length of the Top View

1. Draw a vertical projector through b_1' and it meets the horizontal line through point a at b_1. Taking a as centre ab_1 as radius draw the arc to meet the horizontal line through b_2 at b. The line ab is the top view of the line AB.

To draw the Front View of the line

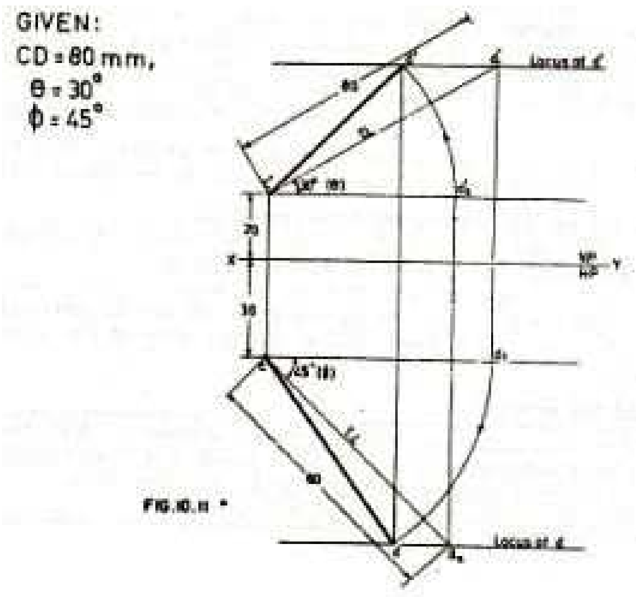
2. Draw a vertical projector through b_2 and it meets the horizontal line through point a' at b_2'. Taking a' as centre ab_2' as radius draw the arc to meet the horizontal line through b_1' at b'. The line a'b' is the front view of the line AB.

3. The vertical projector aa' and bb' are end projectors of point A and B respectively.

4. The horizontal distance between aa' and bb' is the distance between end projectors of A & B.

Example: 5

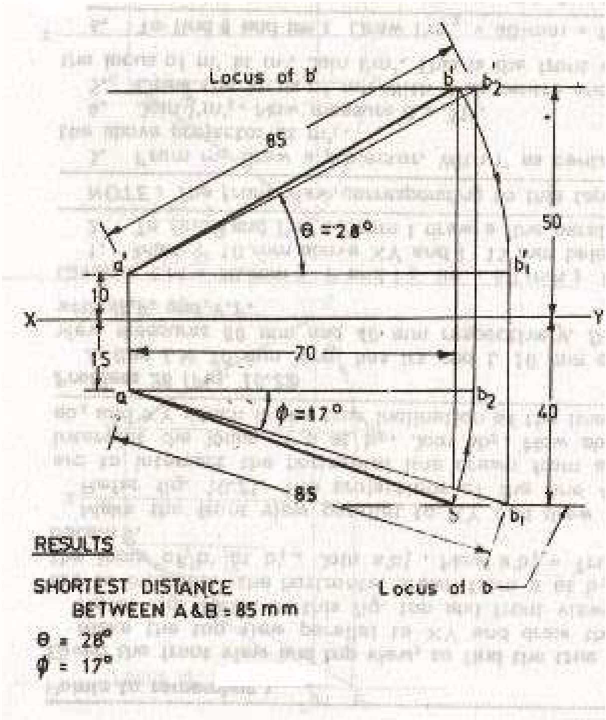
A line CD 80mm long is inclined at 30^0 to HP and 45^0 VP. The point C is 20mm above HP and 30mm in front of VP. Draw the projections of the line.



a. Draw the horizontal reference line XY.
b. Mark c' 20mm above XY.
c. On the vertical projector through a', mark c 30mm below XY. From c' draw a horizontal line and draw a line at 30^0 to XY and mark d_1' such that c'd_1'= True length=80mm. Draw the locus of point D in VP by drawing a horizontal line through d_1'.
d. From c draw a horizontal line and draw a line at 45^0 to XY and mark d_2 such that cd_2= True length=80mm. Draw the locus of point D in HP by drawing a horizontal line through d_2.
e. From d_1' draw a projector to intersect the horizontal line through c at d_1. Now cd_1 is the length of top view. Taking c as centre and cd_1 as radius draw the arc to meet the horizontal line through d_2 i.e. locus of D in HP at d, such that cd is the top view.
f. From d_2 draw a projector to intersect the horizontal line through c' at d_2'. Now c'd_2' is the length of front view. Taking c' as centre and c'd_2' as radius draw the arc to meet the horizontal line through d_1'i.e. locus of D in VP at d', such that c'd' is the top view.
g. Now d and d' are on the same projector.

Example: 6

A line AB is 85 mm long. It's one end A is 10 mm above HP and 15mm in front of VP, while the other end B is 40 mm in front of VP and 50 mm above HP. Draw the projection of the line.

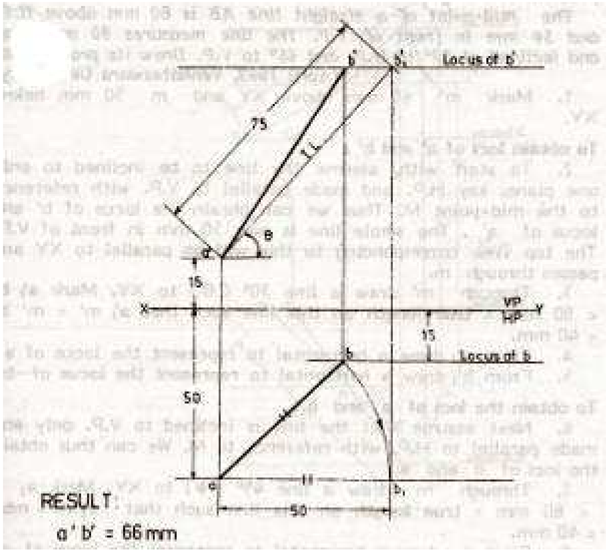


Steps:

1. Draw a horizontal line XY as the reference line.
2. Locate a point 10 mm above line XY and mark as a'.
3. Mark point a 15 mm below XY on the vertical projector through a'.
4 Draw an arbitrary horizontal line parallel to XY, which is 50 mm above which represents locus of b' in VP
5. Draw an arbitrary horizontal line parallel to XY, which is 40 mm below it which represents locus of b in HP.
6. Considering point a' as center and radius = 80 mm, draw an arc that intersects line locus of b' at point b_2'. Here a'b2' is the true length in elevation.
7. Considering point a as center and radius = 80 mm, draw an arc that intersects line locus of b at point b_1. Here ab_1 is the true length in plan.
8. Draw a horizontal line through a', from b_1 draw a perpendicular upward such that these intersects at b_1'.
9. Considering point a' as center and radius = a'b_1' draw an arc to touch line locus of b' at b'.
10. Hence a'b' is the front elevation.
11. Draw a horizontal line through a and from b_2' drop a perpendicular below such that these intersect at b_2.
12. Considering point a as center and radius = ab_2, draw an arc to touch line locus of b at b_2.
13. Hence ab is the top view.

Example: 7

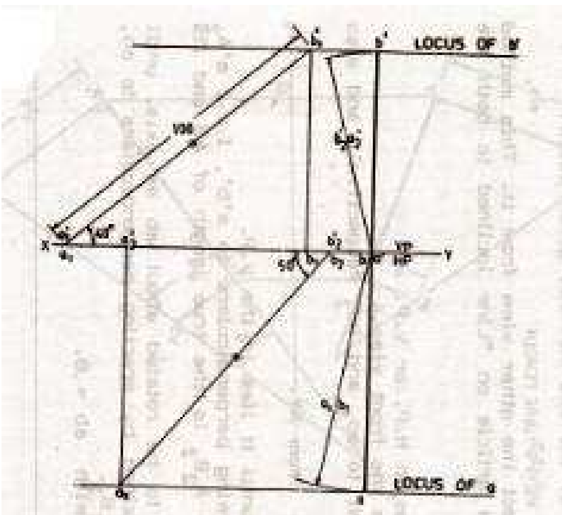
A line of length 75mm has one of its ends 50mm in front of VP and 15mm above HP. The top view of the line is 50mm long. Draw and measure the front view. The other end is 15mm in front of VP and is above HP.



1. Point A is 15mm above HP and 50mm in front of VP, mark a’ 15 mm above XY and a 50 mm below XY on the same projector.
2. Point B is 15 mm in front of VP draw a horizontal line 15 mm below XY to represent locus of b.
3. The top view of the line is 50 mm. Taking a as centre and 50 mm as radius draw an arc to intersect the locus of b at b. Now ab is the top view of the line.
4. With a as centre and ab as radius draw an arc to intersect the horizontal line through a at b_1.
5. Taking a’ as centre 75 mm as radius draw an arc to intersect the projector drawn from b_1 at b_1'.
6. Draw a horizontal line through b_1' to represent the locus of b’.
7. From b draw a projector to intersect the locus of b’ at b’.
8. Join a’b’ which is the front view of the line.

Example: 8

A line AB of length 100mm has one of its ends VP and the other end touching HP. The angle of inclination with HP and VP are 40^0 and 50^0 respectively. Draw the projections.

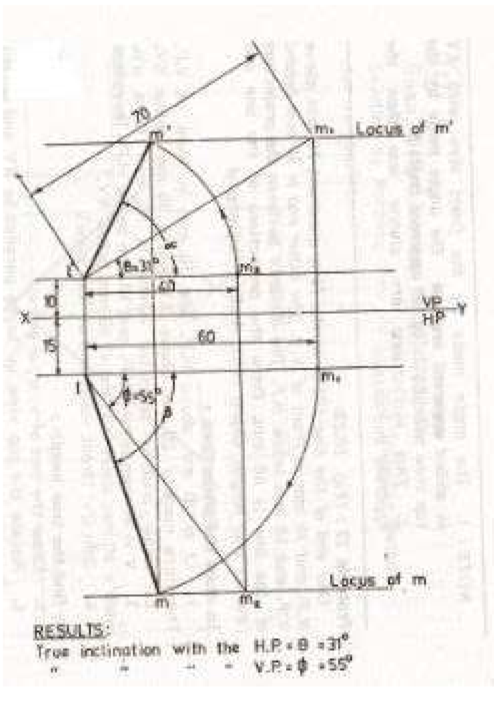


Steps;

1. Let A be the point touching the HP and B be the point touching VP. Thus a’ and b will lie on XY.
2. With reference to B, rotate the line to be parallel to VP keeping $\Theta=40^0$.
3. Mark any point a_1’ on XY to represent front view of A in above position. Draw the front view a_1’b_1’= 100mm=the true length and true inclination 40^0 with HP.
4. From b_1’ draw a horizontal line to represent locus of b’.
5. a_1b_1 is the corresponding top view.
6. Take another point b_2 on XY. Draw a line from b_2 at 50^0(Ø) to XY and mark a_2 such that a_2b_2= 100mm=true length.
7. Draw a horizontal line through a_2 to represent locus of a.
8. Draw the front view a_2’b_2’ on XY corresponding to a_2b_2.
9. Mark any point a’ on XY. With a’ as centre and a_2’b_2’ as radius draw an arc to cut the locus of b’ at b’ such that a’b’=b_1b_1’. A’b’ is the front view perpendicular to XY.
10. With b as centre and a_1b_1 as radius draw an arc to cut the locus of a at a,so ab is the to view, such that ab = a_2’b_2’

Example: 9

A line LM of length 70mm has its end L 10mm above HP and 15mm in front of VP. The top view and front view of the line measures 60mm and 40mm respectively. Draw the projections of the line and determine its inclinations with reference planes.



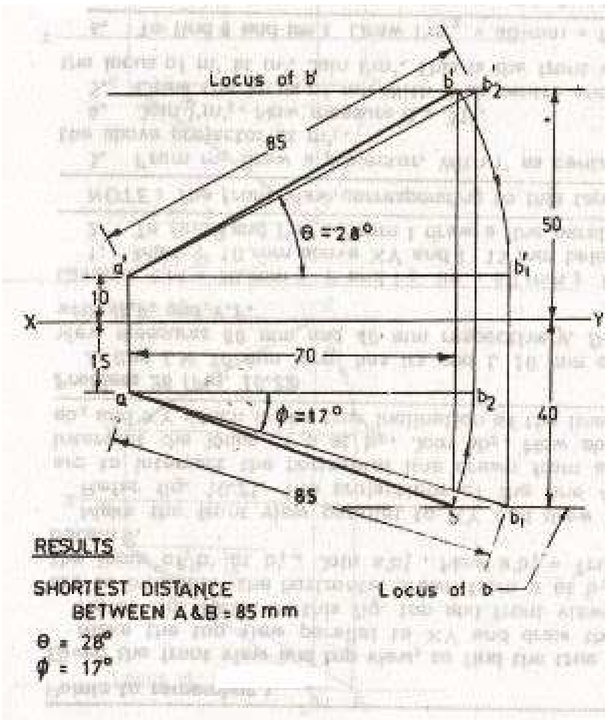
Steps;

1. Point L is 10mm above HP and 15mm in front of VP, mark l’ 10 mm above XY and l 15 mm below XY on the same projector.
2. From l draw a line parallel to XY and mark lm_1=60mm=top view length

3. From m_1 draw a projector. With l’ as centre and true length =70mm as radius draw an arc to intersect the above projector at m'_1.
4. Join l’ m'_1 and measure ‘ϴ’.
5. Draw the locus of m’ through m'_1. With l’ as centre and front view length=40mm as radius draw an arc to intersect the locus of m’ at m’. Join l’m’, which is the front view.
6. Draw $l'm'_2$=40mm=front view and parallel to XY.
7. From m'_2 draw a projector. With l as centre and true length =70mm as radius draw an arc to intersect the above projector at m_2.
8. Join lm_2 and measure Ø (Inclination of line with VP).
9. Through m_2 draw the locus of m. With l as centre and 60mm top view as radius draw an arc to cut the locus of m at m. Join lm(top view)

Example: 10

The distance between end projectors of two points A & B is 70mm. Point A is 10mm above HP and 15mm in front of VP. Point B is 40 mm in front of VP and 50 mm above HP. Find the length of the line and inclinations with reference planes. Draw the projections of the line.



Steps:

1. Draw a horizontal line XY as the reference line.
2. Locate a point 10 mm above line XY and mark as a’.
3. Mark point a 15 mm below XY on the vertical projector through a’ as plan of point A.
4. Draw a projector 70mm from the projector of point A as the distance between end projectors is 70mm
5. Draw an arbitrary horizontal line parallel to XY, which is 50 mm above which represents locus of b’ in VP and it cuts the second projector at b’
6. Draw an arbitrary horizontal line parallel to XY, which is 40 mm below it which represents locus of b in HP and it cuts the second projector at b.
7. With a as centre and ab as radius draw an arc to intersect the horizontal through a at b_2. From b_2 draw a projector to intersect the locus of b’ at b_2’. Now a’ b_2’ is the true length of the line AB.
8. With a’ as centre and a’b’ as radius draw an arc to intersect the horizontal through a’ at b'_1. From b'_1 draw a projector to intersect the locus of b at b_1. Now a b_1 is the true length of the line AB.

PROJECTIONS OF PLANES

Plane figure has only two dimensions; has no thickness. It may be of any shape, such as triangular, square, pentagonal, hexagonal, circular etc.

Types of planes:

1. Perpendicular planes

2. Oblique planes

Perpendicular planes are those planes which are perpendicular to one or both reference planes. These planes can be divided into the following types

a. Perpendicular to one reference plane and parallel to the other.
b. Perpendicular to both reference planes.
c. Perpendicular to one reference plane and inclined to the other.

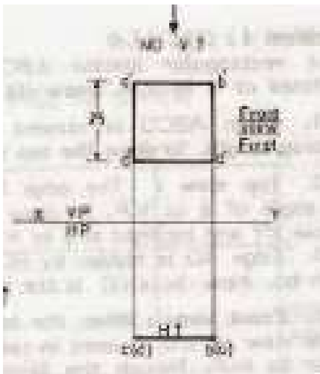
Oblique Planes are those planes which are inclined to both reference planes.

When a plane is parallel to a reference plane the projection of the plane on that reference plane is of true shape of the plane. If the plane is parallel to HP the top view is the true shape of the plane. If the plane is parallel to VP the front view is of true shape of the plane.

When a plane is perpendicular to a reference plane the projection of the plane on that reference plane is a straight line. If the plane is perpendicular to HP the top view is a straight line and if the plane is perpendicular to VP the front view is a straight line.

Example: 1

A square lamina ABCD of side 25mm each is perpendicular to HP and parallel to VP. Draw the projections.

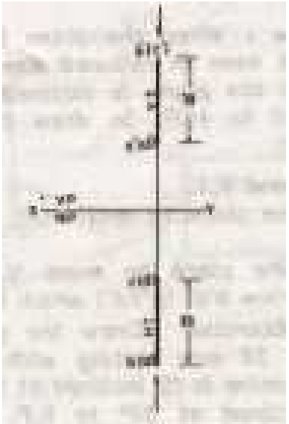


Steps:

1. Since the plane is parallel to VP the front view is the true shape and size i.e. square shape of side 25mm each. The front view a’b’c’d’ is drawn above XY as a square of side 25mm.
2. When the plane is viewed from the top, edge BC is seen in true length and parallel to VP. So draw the top view bc (true length) parallel to and below XY. In the top view ad coincides with bc and is marked as (a)(d.)

Example:2

A square lamina ABCD of side 30mm each is perpendicular to both HP and VP. Draw the projections.

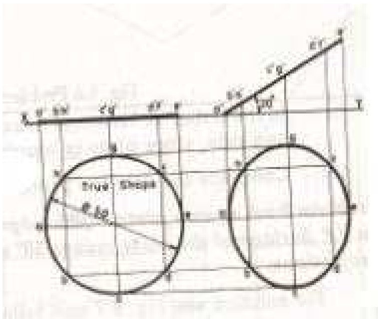


Steps:

1. In front view edge AB is seen in true length. It is above and perpendicular to XY. Draw its front view a’b’.
2. Edge dc is hidden by AB and its front view d’c’ coincides with a’b’
3. In top view edge BC is seen in true length. Draw the top view bc below and perpendicular to XY.
4. a and d are hidden. So in top view mark them as (a)(d) coinciding with bc.

Example: 3

A circular plane of 50mm diameter is resting on HP on one of its points of the periphery with surface of the plate perpendicular to VP and inclined to HP by 30^0. Draw the projections.

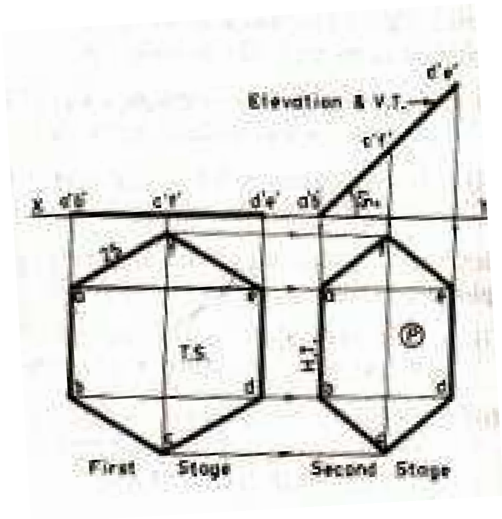


Steps:

1. Draw XY line.
2. Assuming circular plane lying on HP, so the top view will be a circle of same size and its elevation will be a straight line on XY. Draw the top view a circle of diameter 50mm. Project the elevation on XY. Divide the circle into 8 equal parts and mark equal spaced 8 points on the periphery.
3. Rotate the elevation by 30^0 with XY as the plane is inclined to HP.
4. Draw projectors from all marked points of the elevation and horizontal line of the corresponding points from the top view at previous stage to get new top view by intersections. Join them by smooth curves to get the top view.

Example: 4

A regular hexagonal plane, 25mm side each is resting on HP on one of its sides. The surface is perpendicular to VP and inclined to HP by 45^0. Draw its projection.



Steps:

1. Draw the XY line.
2. Since the plane is perpendicular to VP the front view will be a line.
3. Assuming the plane parallel to HP, draw the top view as a regular hexagon abcdef of side 25 mm each with one of its edge ab perpendicular to VP, since the surface is resting on HP on one side.
4. Draw the elevation a’b’c’d’e’f’ by projecting this true shaped top view.
5. Rearrange the elevation to new position a’b’c’d’e’f’ keeping a’b’ on XY line and straight line elevation making 45^0 with XY.
6. Draw projectors from all points on the elevation and draw horizontal lines from corresponding point on the top view in the 1^{st} stage to get the new top view by intersections. Join them to get the top view. abcdef.
7. Elevation and plan in the 2^{nd} stage are the projections of the plane.

PROJECTION OF SOLIDS

Solids

A 3-D object having length, breadth and thickness and bounded by surfaces which may be either plane or curved, or combination of the two.

- Classified under two main headings
  - Polyhedron
  - Solids of revolution
- **Polyhedra**

  A solid bounded by planes called faces.
  - **Tetrahedron**, **Cube**, **Octahedron**, **Dodecahedron**, **Icosahedrons**

    When all the faces are equal in shape and size, the polyhedral is said to be regular
  - **Prism** – A polyhedron having two equal faces called bases or ends, parallel to each other and joined by faces which are parallelograms.

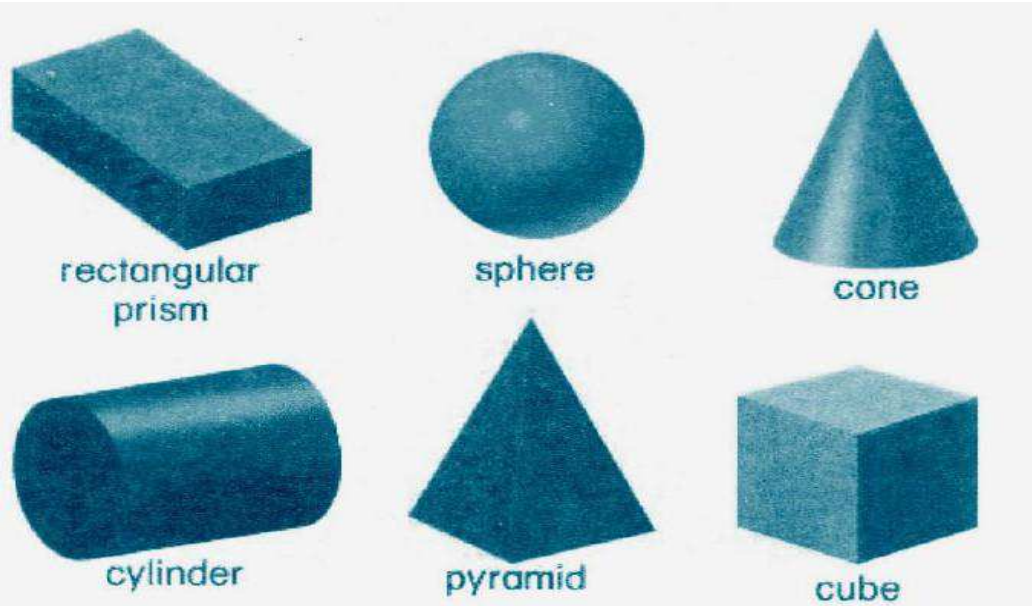
    A right and regular prism has its axis perpendicular to the bases and the bases are regular polygons. All faces are rectangles and are perpendicular to the bases
  - **Pyramid** – A polyhedron having a plane as its base and a number of triangular faces meeting at a point called the vertex or apex.

    A right and regular pyramid has its axis perpendicular to the base and the base is is a regular polygon. All faces are isosceles triangles

Prisms and pyramids are named according to the shape of their bases.

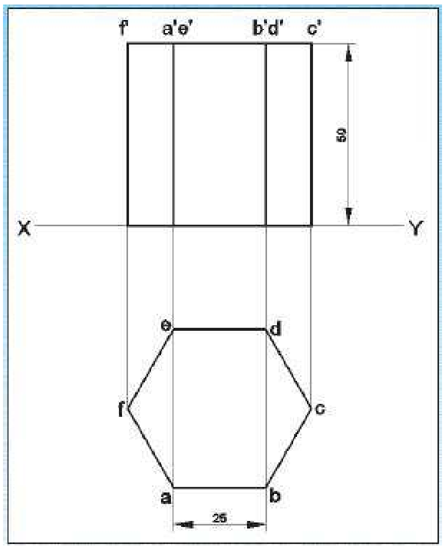
- **Solids of revolutions**

  A solid generated by revolution of a plane about an axis
  - **Cylinder** – A right circular cylinder is a solid generated by the revolution of a rectangle about one of its sides
  - **Cone** – A right circular cone is a solid generated by the revolution of a right-angled triangle about one of its perpendicular sides
  - **Sphere** – A solid generated by the revolution of a semi-circle about its diameter
  - **Frustum** – A solid obtained by cutting a pyramid or a cone by a plane parallel to its base
  - **Truncated** – A solid obtained by cutting a pyramid or a cone by a plane inclined to its base.



PROJECTION OF SOLIDS WHEN ITS AXIS PERPENDICULAR TO ONE REFERENCE PLANE AND PARALLEL TO THE OTHER

Case (1) Axis perpendicular to the H.P and Parallel to the V.P
EXAMPLE:-1
Project the front view and top view of a hexagonal prism of 25 mm base edges and 50 mm height, having two of its vertical rectangular faces parallel to V.P; and its base resting on H.P.

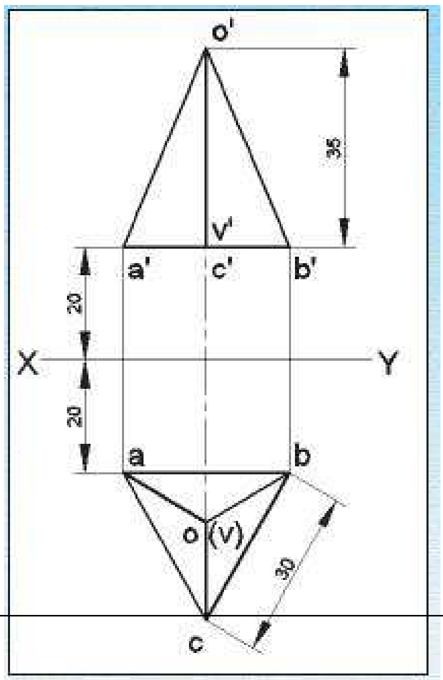


Step:

1. As the axis is perpendicular to HP the top view is hexagonal (i.e. the shape of the base top) and the hexagon abcdef ($a_1b_1c_1d_1e_1f_1$) is to be drawn with two sides parallel to XY representing faces of the prism in the top view.

2. Draw the projectors from the points of the top view and mark $a'_1b'_1c'_1d'_1e'_1f'_1$ on XY. Draw a horizontal line at height 50mm, since the height is 50mm and draw projectors from the $a'_1b'_1c'_1d'_1e'_1f'_1$points till intersects the line. Mark the corresponding points as a'b'c'd'e'f'.

EXAMPLE:-2
A triangular pyramid with 30 mm edges at its base and 35 mm long axis resting on its base with an edge of the base near the V.P, parallel to and 20 mm from the V.P; Draw the projections of the pyramid, if the base is 20 mm above the H.P



Steps:

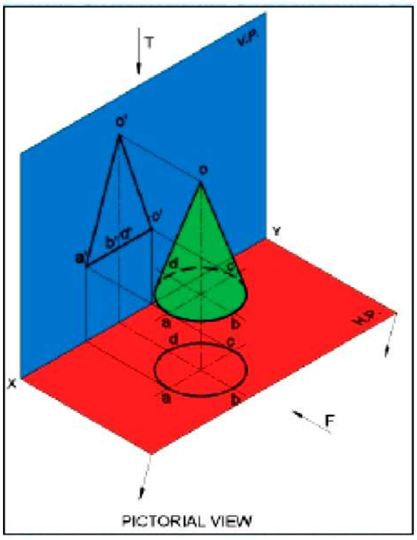
1. Draw the top view of the base abc an equilateral triangle of side 30mm each with ab parallel to XY and 20mm from XY. Find the centre of the triangle as o by drawing perpendicular bisectors of any two sides. Join oa, ob, and oc.
2. Draw the front view of the base as a'c'b' on XY.. Mark o' the front view of o at 35mm above XY on the projectors from o, as the height is 35mm.
3. Join o' with a', b' and c' to get the front view.

Example: 3

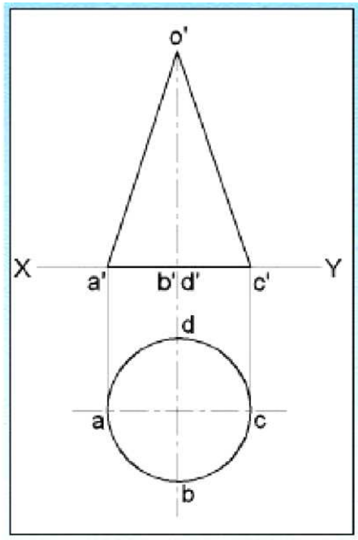
Draw the projection of a right circular cone resting on HP

Steps:

1. Top view gives the true size of the base i.e. a circle. Draw a circle of given diameter. Mark 8 points at equal distance on the periphery. Mark the centre of the circle.
2. Draw projectors from all points on the periphery and mark on XY as front view a'b'c'd'e'f'g'h' . Draw the front view of the centre o' at height above XY. Join o' and other points of the base to get the front view.

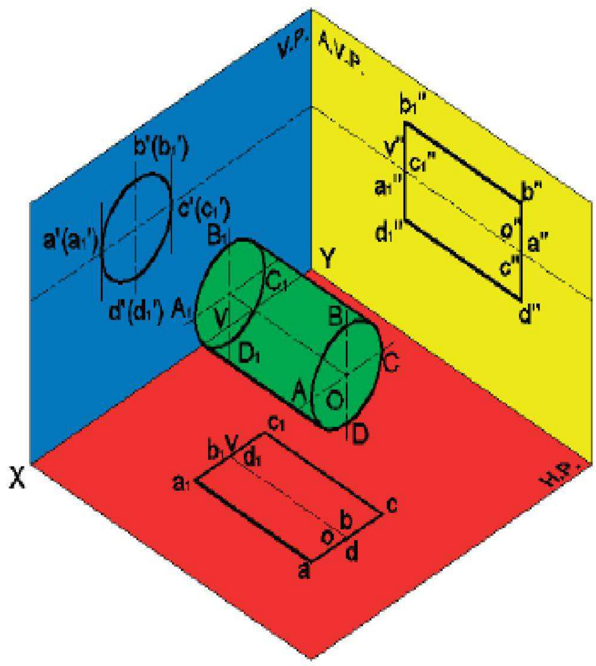


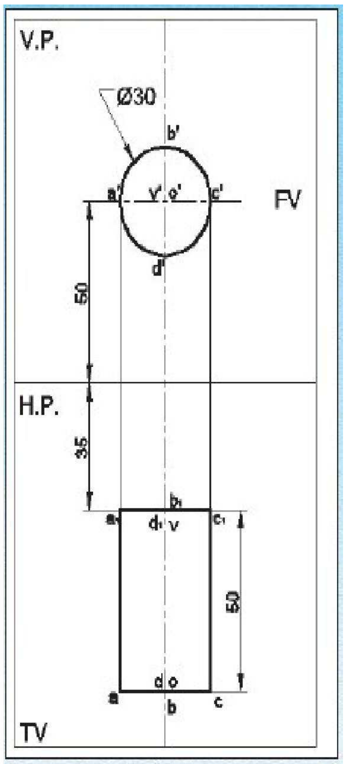
PICTORIAL VIEW



PROJECTION OF SOLIDS WHEN ITS AXIS PERPENDICULAR TO ONE REFERENCE PLANE AND PARALLEL TO THE OTHER

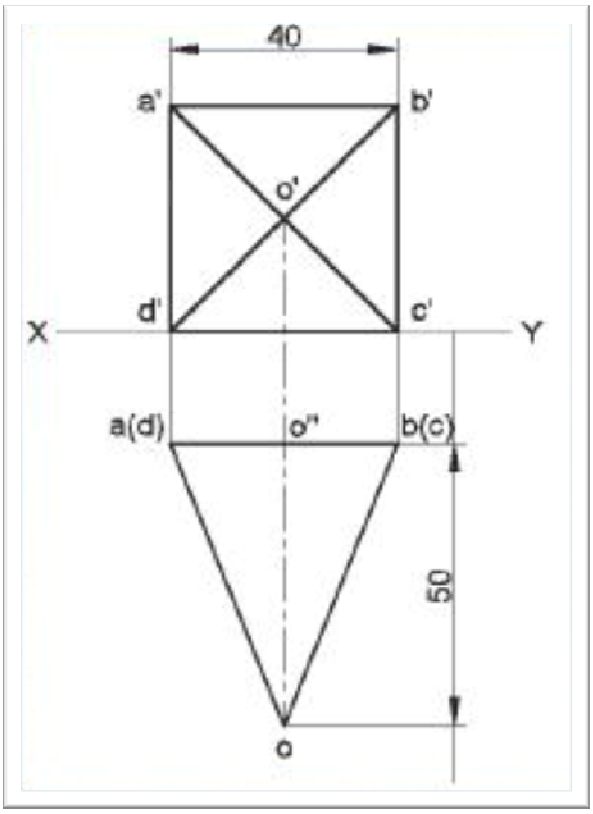
Case (2) Axis perpendicular to the V.P and Parallel to the H.P





EXAMPLE:-4

Draw the front view and top view of a square pyramid of base edge 40 mm and axis 50 mm long resting on HP and axis perpendicular to V.P. The vertex is in front

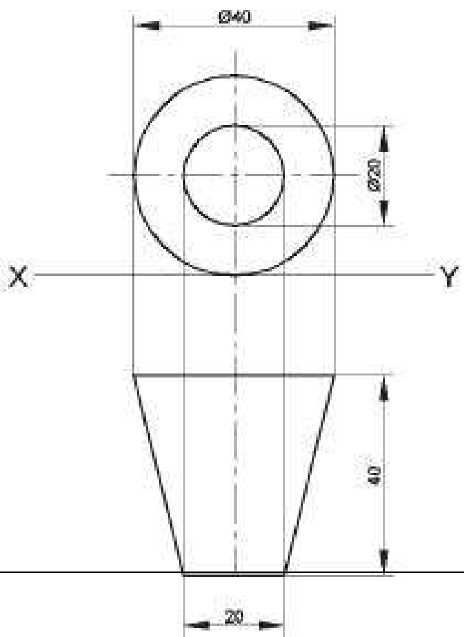


Steps:

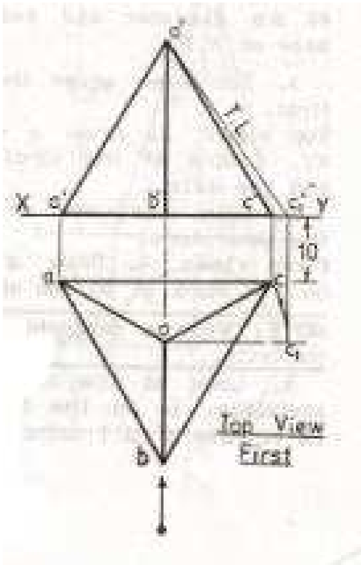
1. Since the axis is perpendicular to VP the front view is true size of the base.
2. Draw the top view of the a'b'c'd' with c'd' on XY. Draw the diagonal a'c' and b'd' to get the front view of the apex o'.
3. Draw projector below XY and draw the top view a(d) and b(c) at any distance from XY.
4. Draw the apex o at 50mm below ab on the projector from o'. Join oa and ob to get the top view.

EXAMPLE:-5

The frustum of the cone of 40 mm base diameter and 20 mm cut face diameter, rests on H.P with its 40 mm long axis parallel to H.P and at right angles to V.P, the cut face is in front. Project its **front view** and **top view**



Example: 6
A tetrahedron of side 40mm rests on HP. Draw the projections when one of its edges parallel to and 10mm in front of VP.



Steps;

1. Draw abc equilateral triangle with side 40mm each with ac parallel to and 10 mm below XY as the top view is the true size of base.
2. Draw the centre of the triangle o (by drawing perpendicular bisectors of any two sides and their intersection point). Join oa, ob and oc to get top view.
3. Draw the front view of base a’b’c’ on XY.
4. Since none of the slant edge is parallel to VP no slant edge will be true length. Hence to mark o’ turn the top view of any one of the slant edge parallel to XY i.e. o as centre and oc as radius draw an arc to cut the line parallel to XY at c_1. Project c_1 and get c'_1 on XY.
5. With c'_1 as centre and 40mm as radius draw an arc to cut the projector drawn from o at o’.
6. Draw a’b’c’.o’a’,o’b’ and o’c’ to get the front view

CHAPTER-7

SECTIONS OF SOLIDS AND DEVELOPMENT OF SOLIDS

SECTIONS OF SOLIDS

The surface obtained by cutting an object by section plane is called **section** or **cut surface.**
The projection of the section of an object with its remaining portion is called **sectional views**.
The true shape of the section is obtained by viewing the object normal to the cut surface and projecting it on a plane parallel to the section plane.

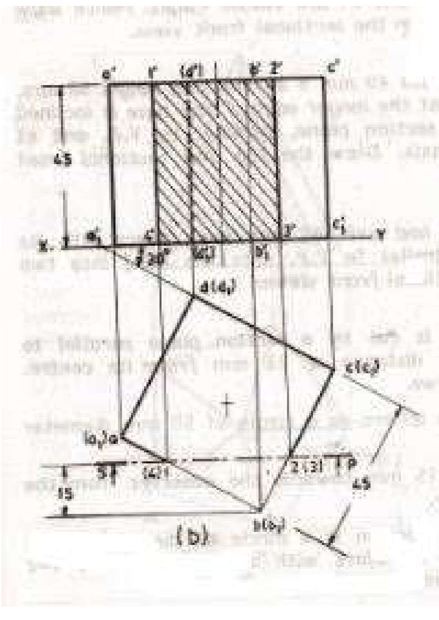
Types of Section Planes:

- Section plane perpendicular to HP and parallel to VP
- Section plane perpendicular to VP and parallel to HP
- Section plane perpendicular to HP and inclined to VP
- Section plane perpendicular to VP and inclined to HP

Section plane perpendicular to HP and parallel to VP

Example: 1

A cube of side 45mm rests on HP with one of its face inclined at 30^0 to VP. A section plane parallel to VP cuts the cube at distance of 15mm from the vertical edge nearer to the observer. Draw the top and sectional front view.



Steps.

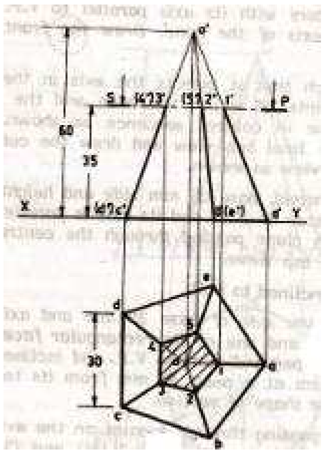
1. Draw the top view as a square abcd ($a_1b_1c_1d_1$) of size 45 mm, with one side inclined at 30^0 to XY and front view of the cube for the given position. Name the corner points.
2. Draw Section plane parallel to XY and 15mm from the vertical edge $b(b_1)$ nearer to the observer in the top view.
3. Name section points 1 and 2 where it cuts edge ab and bc respectively and name (3) and (4) where it cuts the invisible edge $(C_1)(b_1)$ and $(b_1)(a_1)$ respectively. Show the remaining portion of the cube by thick lines.
4. Project the section points on the corresponding edges in the front view i.e. 1’ on a’b’, 2’ on b’c’, 3’ on $c'_1b'_1$ and 4’ on $b'_1a'_1$ respectively.
5. Join 1’2’3’4’ by thick line and hatch this area as cut surface.

Section plane perpendicular to VP and parallel to HP

As plane is perpendicular to the VP the front view is a line and as plane is parallel to HP the top view is the true shape of the plane.

Example: 2

A pentagonal pyramid of side of base 30mm each and height 60 mm rests on HP on its base. One of its edges of base is perpendicular to VP. It is cut by a section plane perpendicular to VP and parallel to HP at 35mm above the base. Draw the sectional top view.

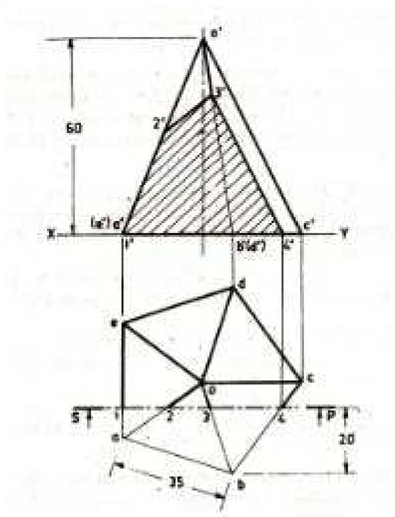


Steps:

1. Draw the top view of the pyramid abcde pentagon with side cd perpendicular to XY. Mark o centre of the pentagon. Join oa,ob,oc,od,oe.
2. Draw the front view a’b’c’d’e’ of base corner points on XY. Mark o’ at height 60mm on the projector from o. Join o’c’(d’), o’a’, o’b’(e’).
3. Draw the sectional plane (SP) parallel to XY at height 35mm above XY in the front view. cutting sides of pyramid.
4. Mark points 1’,2’,3’ cutting the visible edges o’a’, o’b’ and o’c’ respectively. Mark (4’) and (5’) where the SP cuts invisible edges o’(d’) and o’(e’) respectively.
5. Show the remaining portion of pyramid a’b’c’(d’)(e’) and the slant edges 1’a’,2’b’,3’c’, (4’)(d’) and (5’)(e’) as thick lines in the front view.
6. Project the section points on the corresponding edges in the top view, i.e. mark 1 on oa, 2 on ob and so on.
7. Join 12345 by thick lines and hatch this area. This cut surface is true surface of the section.

Example: 3

A pentagonal pyramid of side of base 35mm each and height 60 mm rests on HP on its base. One of its edges of base is perpendicular to VP. It is cut by a section plane perpendicular to HP and parallel to VP at distance of 20mm from the corner of the base nearer to the observer. Draw the sectional front views.



Steps:

1. Draw the top view and front views of the pyramid as per the position.
2. Draw SP parallel to XY and 20mm from b as shown. Name the points 1,2,3 and 4 where it cuts the visible edges ea, oa, ob and bc respectively.
3. Show the remaining portion of pyramid as thick lines in top view.
4. Project the above section points on the corresponding edges in the front view. Mark 1’,2’,3’, and 4’ on a’e’, o’a’, o’b’ and b’c’ respectively.
5. Join 1’2’3’4’ by thick lines and hatch this area. This is the true shape of the section.

DEVELOPMENT OF SOLIDS

Development of surface of an object means the unrolling or unfolding of all surfaces of the object on a plane.

Every point on the development shows the true length of the corresponding line on the surface which is developed.

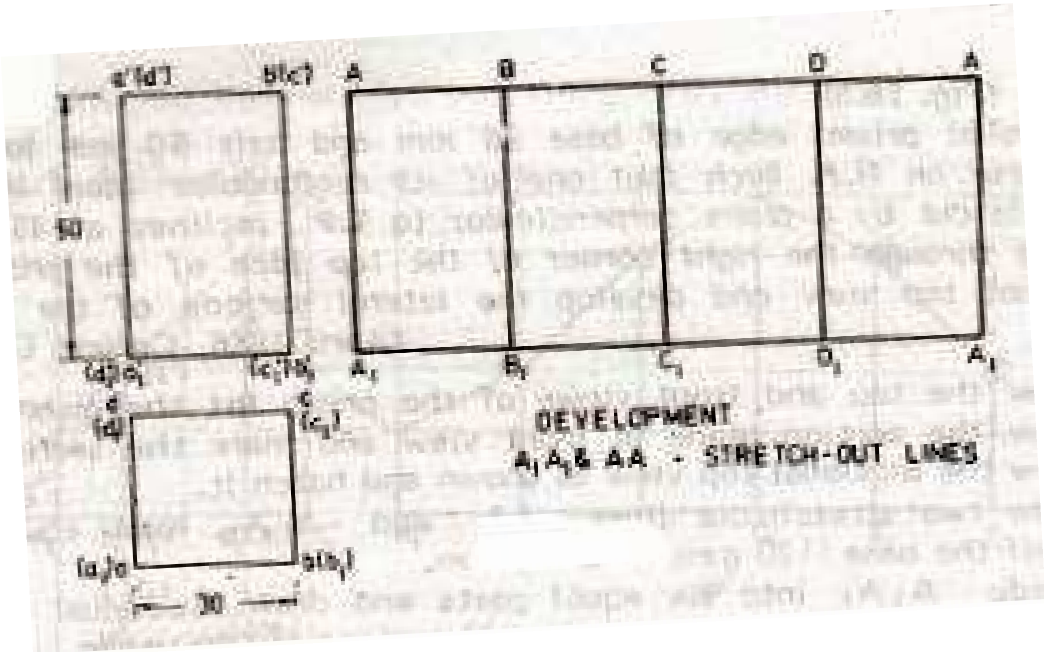
Methods of development

- Parallel –line development: Used for development of prism and cylinder.
- Radial-line development: Used for development of pyramids and cone.
- Triangulation development:
- Approximate development.

Example: 1

Draw the development of the lateral surface of a right square prism of edge of base 30mm and axis 50mm long.

Draw the top view and front view of the prism and name the corners.

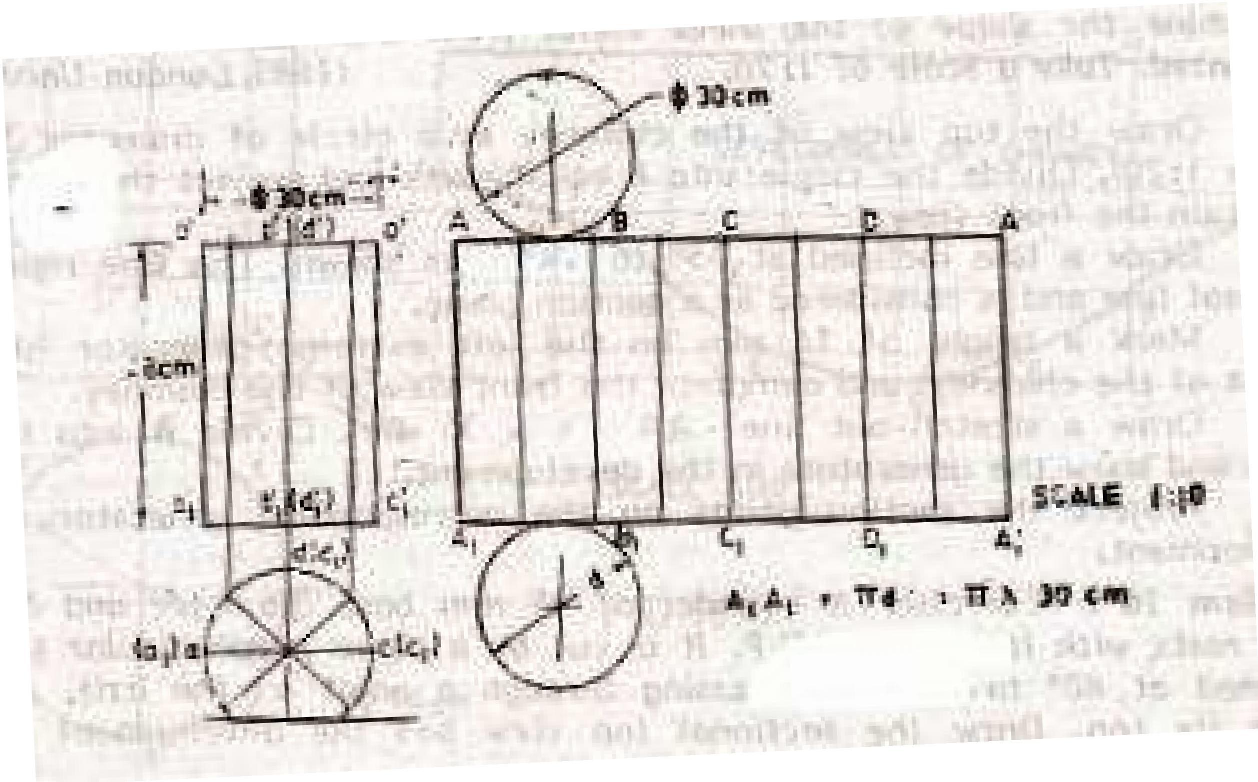


Steps:

1. Draw the top view and front view of the prism and name the corners.
2. It consists of four equal rectangles of size 50mm X 30mm in contact and in sequence. So draw a rectangle A_1 A_1AA such that A_1 A_1 = perimeter of the base of the prism and AA_1= 50mm height
3. On the line A_1 A_1 mark four equal divisions A_1B_1,B_1C_1, etc. each equal to the side of base=30mm
4. Erect perpendiculars at B_1,C_1 and D_1. Darken the four rectangles which give the development of the lateral surface of the prism.

Example:

Draw the development of the complete surface of a cylindrical drum with lid. Diameter is 30cm and the height is 1.6 times the diameter.

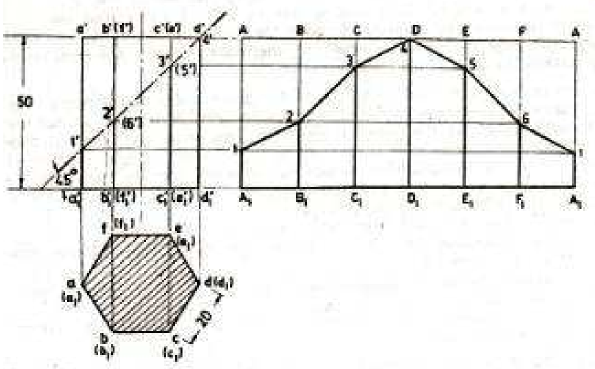


Steps:

1. Draw the top view and front view of the cylinder.
2. Draw a rectangle of size π X 30cm and divide it into eight equal parts and mark points accordingly.
3. Draw the circle at top and bottom at the extreme ends.

Example-3

A hexagonal prism of 20 mm base edges and 50 mm height, having two of its vertical rectangular faces parallel to V.P; and its base resting on H.P. It is cut by a plane perpendicular to VP inclined at 45^0 to HP and passing through the right corner of the top face of the prism. Draw the sectional top view and develop the lateral surface of the truncated prism.

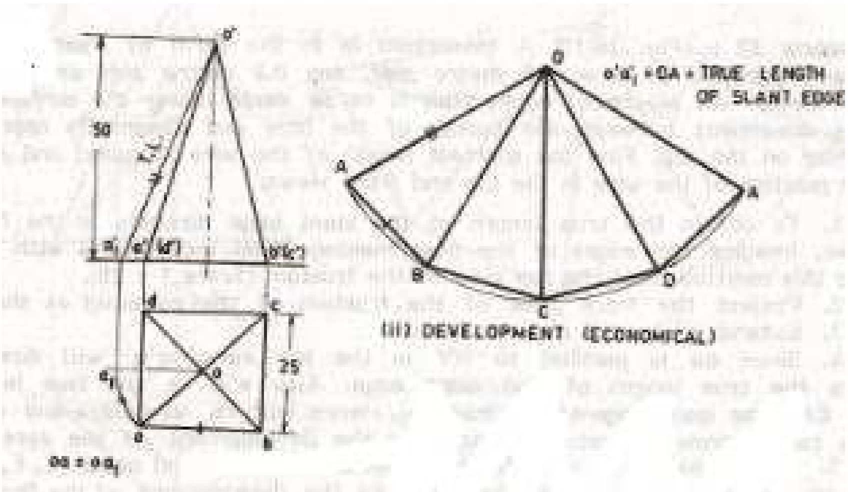


Steps:

1. Draw the top view and front view of the cylinder.
2. Draw the sectional plane in the front view and mark the section points.
3. Draw the sectional top view as shown and hatch.
4. Draw the two stretch-out lines AA and A_1A_1 each equal to the perimeter of the base (120mm)
5. Divide A_1A_1 into six equal parts an draw six equal rectangles to represent development of the lateral surface of the prism.
6. From the section point 1 draw a horizontal line and mark 1 on AA_1. Simillarly obtain points 2,3,4,5, 6 I the development.
7. Join 12, 23, 34,……61 as straight lines and darken the development of the lateral surface of the truncated prism.

Example 4

Draw the development of the lateral surface of a square pyramid, side of base 25mm and height 50mm, resting on HP on base. One edge of the base is parallel to VP.

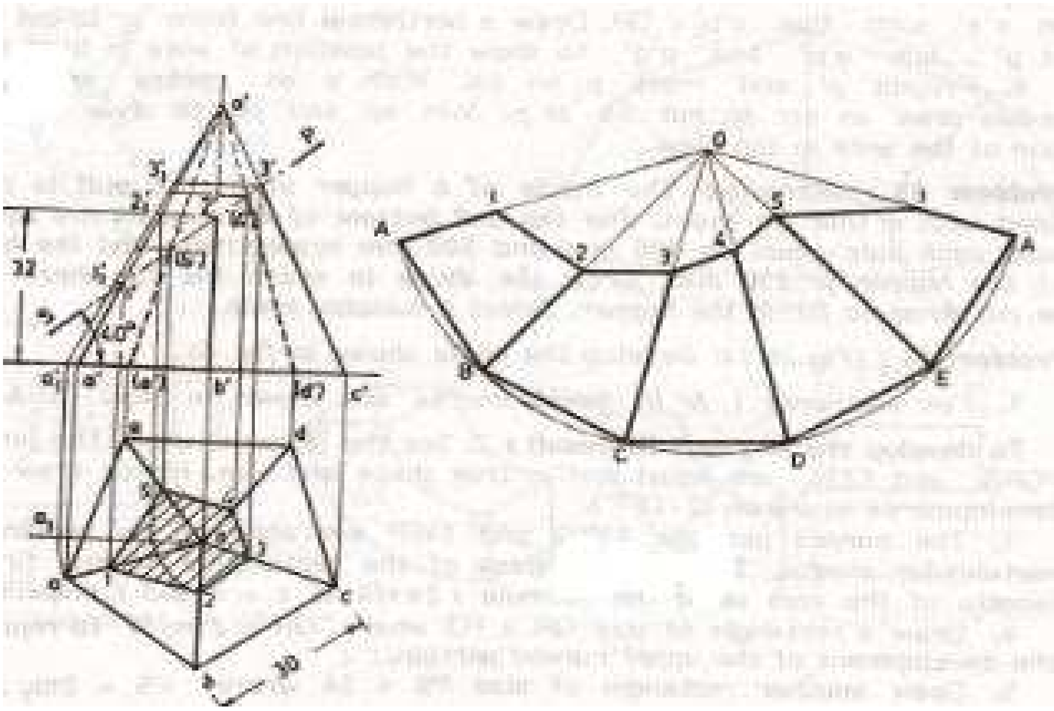


Steps:

1. Draw the top view and front view of the pyramid.
2. The true length of the slant edge is required for its development, since none of the slant edge is parallel to VP true length cannot be obtained directly from front view. To get the true length of slant edge (say OA), make oa parallel to XY and draw an arc with o as centre and oa as radius to cut the horizontal line at a_1. So $o'a'_1$ is the true length of the slant edge OA.
3. With O as centre and $o'a'_1$ as radius draw an arc. On this arc mark 4 equal divisions, i.e., chord AB=BC=CD=DA=25mm. Complete the triangles OAB,OBC,OCD and ODA by thick lines which gives the development of the lateral surface of a square pyramid.

Example: 5

A pentagonal pyramid, side of base 30mm and height 52mm, stands on its base on HP and one edge of the base is parallel to VP. It is cut by a section plane perpendicular to VP and inclined at 40^0 to HP and passing through a point on the axis 32mm above the base. Draw the sectional top view and the development of the lateral surface of a truncated pyramid

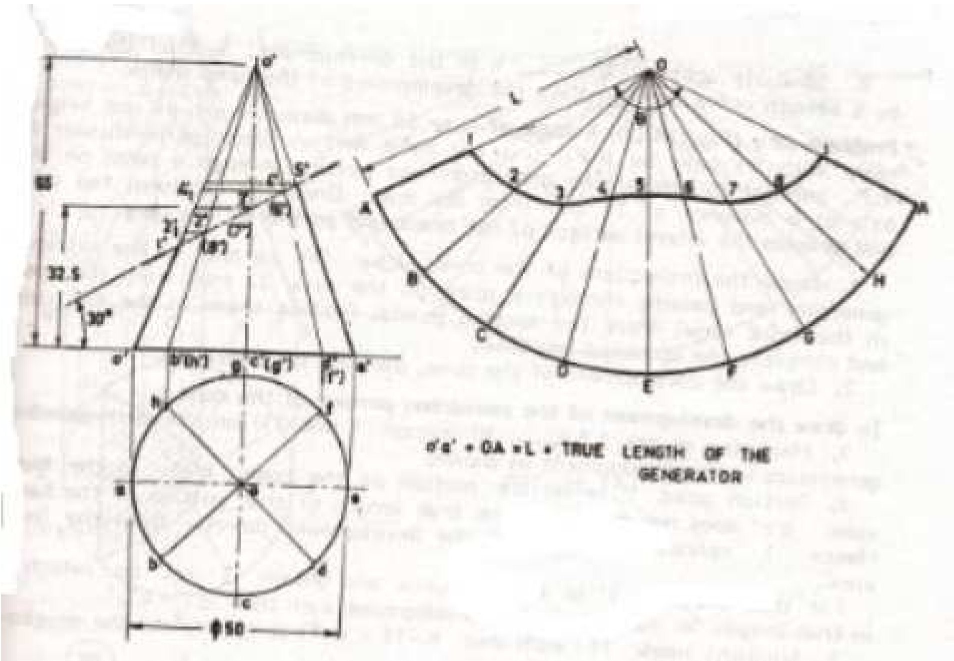


Steps:

1. Draw the top view and front view of the pyramid.
2. Find the true length of the slant edge and draw the development of lateral surface of the pyramid.
3. Draw the section plane in front view and mark the section points.
4. Draw the sectional top view and hatch the cut surface.
5. To find the true length of the remaining portion of the slant edges draw horizontal lines through the section points 1’, 2’, 3’, 4’, etc to cut o’a’$_1$(True legth of slant edge OA) at 1_1’,2’$_1$, 3’$_1$.
6. With O as centre and o’1’$_1$as radius draw an arc to cut OA at 1. Similarly obtain points 2, 3, 4, 5, and complete the development of the truncated pyramid.

Example: 6

A cone of base 50mm diameter and height 65mm rests with its base on HP. A section plane perpendicular to VP and inclined at 30^0 to HP bisects the axis of the cone. Draw the development of the lateral surface of the truncated cone.

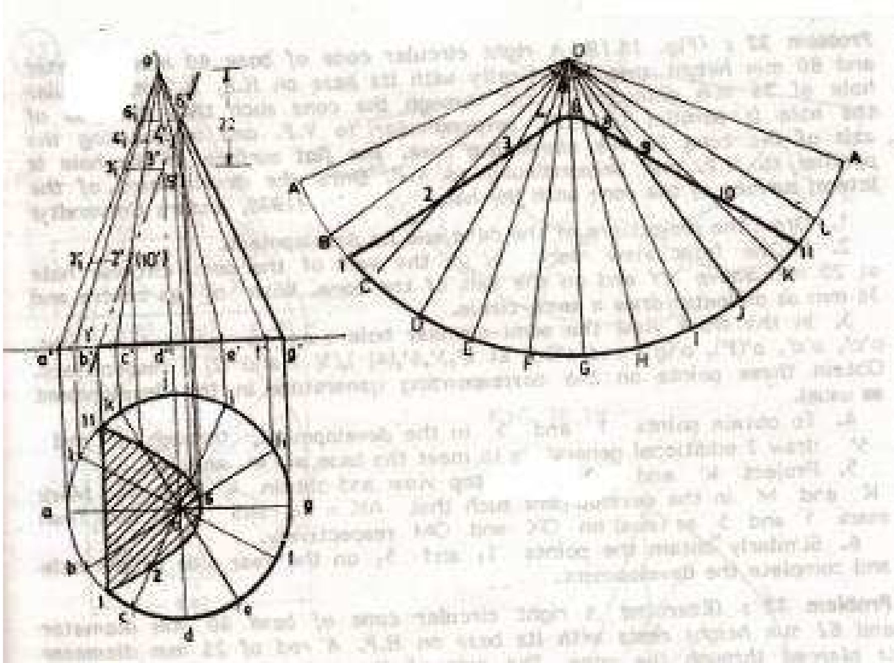


Steps:

1. Draw the top and front views of the cone. Divide the base circle into 8equal parts and show the generators oa,ob,oc, …. and oh in top view and corresponding lines o'a','o'b', o'c', ….. and o'h' in front view.
2. In top view oa is parallel to XY, hence o'a' is equal to the true length L of the generator.
3. Development of the cone is a sector of a circle of radius equal to the length L of the generator. Length of the arc of the sector is equal to the circumference of the base circle (2πr) and the angle subtended by the arc at the centre is Ө.
   a. The LӨ = 2πr'= 360^0 X r. Hence, Ө = 360^0 X r/L.
4. O as centre and L as radius draw an arc subtending angle Ө at O.
5. Divide Ө into 8 equal parts, draw the radial lines OA, OB, OC etc. and complete the development of the cone.
6. Draw the section plane at 30^0 to XY bisecting the axis in front view. Mark the points 1',2', 3' etc.
7. Mark 1 on OA in the development such that O1= o'1'.
8. To mark points2,3, etc draw horizontal line from 2',3' etc on the end generator o'a' at 2_1',3_1' etc. Transfer the distances o'2_1', o'3_1' etc on the respective generators in the development as O2,O3 etc on OB,OC etc respectively.
9. Draw a smooth curve passing through the points 1,2,3, etc and complete the development of the lateral surface of the truncated cone.

Example:

A cone of base 50mm diameter and height 60mm rests with its base on HP. It is cut by a section plane perpendicular to VP, parallel to one of its generator of the cone and passing through a point on the axis at 22mm from the apex. Draw the sectional top view and develop the lateral surface of the remaining portion of the cone.



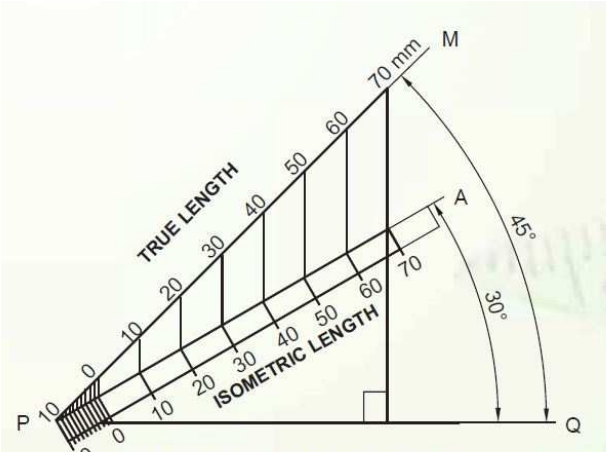
Steps:

1. Draw the projection of the cone. Draw SP parallel to the extreme generator o'a' passing at appoint on the axis 22mm below the apex o' in the front view. Mark the section points1',2',3',4',5',6' ….10'. Project them to the top view. Complete the sectional top view.
2. Draw the development of the cone showing 12 generators as in the above figure.
3. Mark the points 2,3,4,….. 10 on the corresponding generators in the development as described in the previous example.
4. Marked point 1' on the portion of base b'c' in the front view does not represent the true length of that portion of the base. Hence 1 can't be marked in the development directly from the front view. Project 1' to the top view and obtain 1 on bc which is the true length. So mark 1 on the development such that B1=b1.
5. Similarly mark 11 such that K-11=k-11 and complete the development.

ISOMETRIC PROJECTION

The isometric projection of an object is a one plane view drawn with the object so placed with respect to the plane of projection that all the three principal axes appear to be inclined to each other at an equal angle of 120°.

ISOMETRIC SCALE



ISOMETRIC SCALE

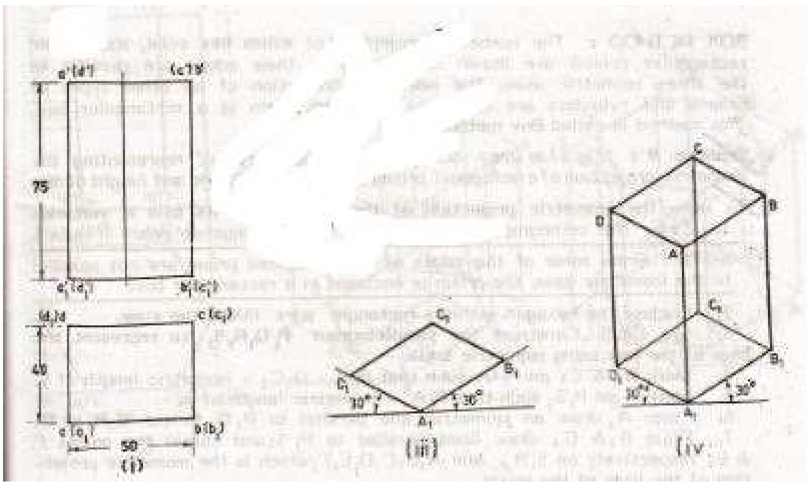
The isometric scale is used to measure the foreshortened length of dimensions of any object to draw the isometric projection. The steps of construction of isometric scale are given below;
(i) Draw a horizontal line PQ.
(ii) Draw the true lengths on a line PM inclined at 45° to the horizontal line.
(iii)Draw another line PA at 30° to the horizontal line.
(iv)Draw the vertical projection of all the points10, 20, 30, 40 etc. on PM to PC .
(v) Complete the scale with the details as shown in the figure.
The lengths shown at the line AB are the isometric lengths to be used to draw the isometric projection.

Difference between Isometric View and Isometric Projection

Isometric View	Isometric Projection
Drawn to actual length	Drawn to Isometric length
When lines are drawn parallel to isometric axes true lengths are drawn	When lines are drawn parallel to isometric axes 0.81 times the true lengths are drawn

Example: 1

Draw the isometric view of a square prism of side of base 35mm and height 65 mm when the axis is vertical.

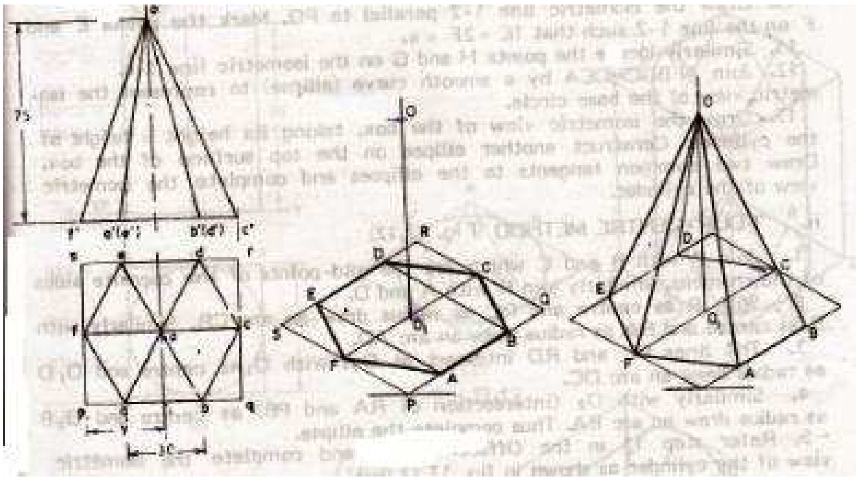


Steps:

1. Draw the top view abcd($a_1b_1c_1d_1$) square of side 35mm each and front view $a'_1(d'_1)$ $b'_1(c'_1)$ b'(c')a'(d') of the prism.
2. Draw a horizontal line mark A_1 on it.
3. Draw two lines at 30^0 with horizontal at A_1 as Isometric axes.
4. Mark B_1 and D_1 such that $A_1B_1=A_1D_1$
5. From B_1 draw a line parallel to A_1D_1 and from D_1 draw a line parallel to A_1B_1. Both meet at C_1.Draw vertical at A_1 to represent 3^{rd} axis. Mark the point A on it at height 65mm above A_1.
6. From B_1, C_1 and D_1 draw vertical lines and mark B, C and D at height 65mm on these respectively.
7. Join ABCD, AA_1, BB_1, DD_1 to get the isometric view of the prism.

Example: 2

Draw the isometric view of a hexagonal pyramid of side of base 30mm and height 75 mm resting on HP with one of its side of base parallel to VP.

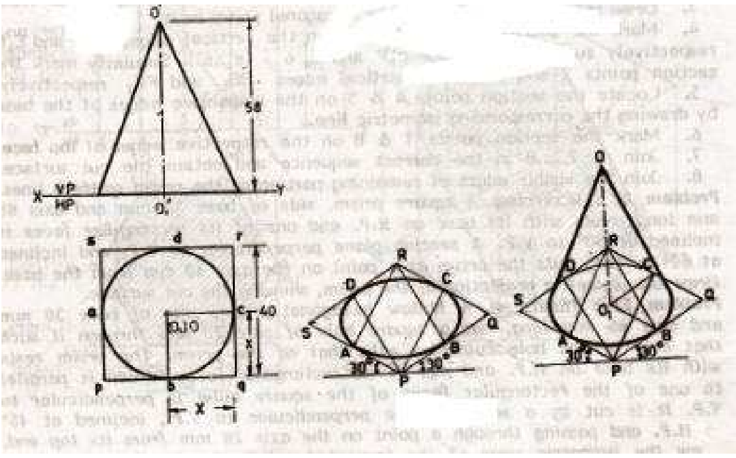


Steps:

1. Draw the top view as hexagonal (i.e. the shape of the base top) and the hexagon abcdef is to be drawn with ab and de sides parallel to XY. Join diagonals to get the centre o.
2. Draw the front view a'b'c'd'e'f' on XY by drawing projectors from respective points and draw o' at height 75mm above XY on the projector from o.
3. Enclose the hexagon in a rectangle pqrs.
4. Draw the isometric view of the base of the pyramid in the parallelogram PQRS.
5. Mark the O_1 on the isometric line FC.
6. From O_1 erect vertical line and mark O such that OO_1= 75mm
7. Join OA,OB,OC,OE and OF to get the isometric view.

Example: 3

Draw the isometric view of the cone of base diameter 40mm and height 58mm when it rests with its base on HP.



Steps:

1. Draw the top view and front view of the cone.
2. Enclose the circle in the top view in square.
3. Draw the rhombus PQRS.
4. Draw the base of the cone as an ellipse by four centre method.

   4.1 Join P with C and D which are the mid points of the opposite sides. Similarly join R with A and B the mid points of opposite sides.

   4.2 With P as centre PC as radius draw arc CD. Like this draw arc AB with R as centre and RA as radius.

   4.3 Find out the intersection point of RA and PD, taking this as centre and radius upto C or B draw the arc BC. Like this find the intersection point of RB and PC, taking this as centre and radius upto A or D, draw the arc BC
5. From B and C draw lines parallel to the isometric axes and obtain O_1.
6. From O_1 draw a vertical line and mark O such that OO_1=58mm.
7. From O draw two tangents to the ellipse and complete the isometric view.

CHAPTER-8

BUILDING DRAWING

Line Plan / Line diagram:

- It is a line sketch drawn not to scale, which indicates the arrangement of rooms, toilet, passage, verandah etc, and position of door / window.
- The dimensions shown in the line diagram are inside to inside dimensions.
- The details given in the line diagram are used to draw the building drawing (i.e., Plan, Elevation and Sections) to a scale.
- This is drawn for the primary approval of the owner before drawing the Plan, Elevation and Sections.

Plan:

- Plan of a building represents a horizontal section of building.
- It is obtained by cutting the building at certain height (generally at window sill level) by a horizontal cutting plane and then, removing the upper part of the building the remaining portion is seen from the top and is projected on the horizontal plane (HP).

Elevation:

- Elevation is one side outward view of a building, which is drawn by projecting that side of the building on a vertical plane (VP). When the building is seen by standing in front of it then, what is seen and projected on the vertical plane (VP) is called **front elevation**.
- Similarly, when the building is seen by standing from any of the side of the building then, what is seen and projected on the VP is called **side elevation.**

Section:

- Section refers to a vertical section of building.
- It is obtained by cutting the building in two parts by vertical plane / planes from the top up to below the foundation depth (i.e. bottom of footing) and one part is considered to be removed and the other remaining part is projected on a vertical plane. The diagram so obtained is the sectional view of the building.

The details of a building can be obtained from the plan, elevations and section from a 2D drawing.

As per the syllabus of only drawing of Plan and Front Elevation of a single room building is there.

IMPORTANT TERMS RELATED TO BUILDING

Super-Structure:

- The portion of the building/structure, which lies above the ground level, is referred as **super-structure.**

Foundation:

- This is the portion of the building, which is constructed below the ground level and is also called as **sub-structure**.
- The main function of foundation is to distribute the load of whole structure over a large area.

Plinth:

- The portion of a building between ground level (GL) and floor level (FL) is called plinth/plinth wall.
- When the thickness of plinth wall is more than super-structure wall, the projected portion of the plinth wall from the super-structure wall is called plinth projection.
- The vertical distance from GL to FL is termed as **plinth height**.
- Generally plinth height of 450mm/600m is provided.

Lintel:

- It is the element of the building, which is provided over the small openings of the doors/windows/ verandah to transfer the load coming over them on to the wall on which they rest.
- Now-a-days RCC (Reinforced Cement Concrete) lintel is provided in the buildings.
- Its size depends on the opening size.
- Depth and width of lintel is generally of 150mm and 300mm respectively.

Chajja/Sun shade:

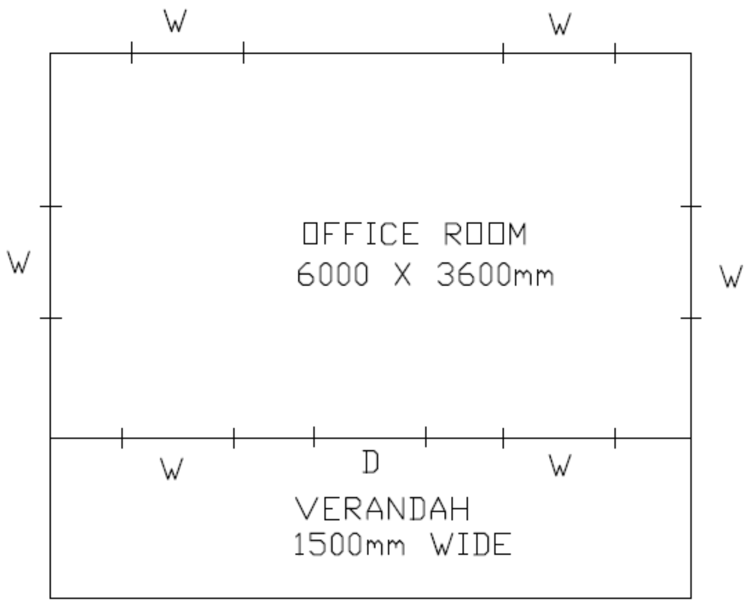
- It is the horizontal/sloping element of the building provided over the openings on external walls and projected from the lintel outward to provide protection from sun and rain.
- Chajja is constructed using RCC.
- Thickness and width of a horizontal chajja is 75mm and 450mm respectively.

Ceiling Height:

- Soffit of the roof slab is termed as ceiling.
- The height of room from the flooring to the ceiling is called ceiling height.

Problem No. 1

Draw the plan and front elevation of the building from the line plan and specifications as given below.



LINE PLAN OF A SINGLE
ROOM OFFICE BUILDING

Given Specifications

1. Wall thickness - 300mm
2. Plinth height - 600mm
3. Plinth wall thickness- 400mm
4. Step
   (i) Trade - 300mm
   (ii) Riser - 150mm
5. Ceiling height for room and verandah- 3000mm
6. Spacing of masonry pillars (3300mmx300mm) in verandah should not exceed 3m
7. Roof slab thickness - 100mm
8. Roof slab projection from the wall (Cornice)- 100mm
9. Chhajja (Sun Shade):
   (i) Thickness- 75mm
   (ii) Width- 450mm
10. Door & Windows Shedule
    (i) Window (W) - 1050 X 1350mm
    (ii) Door (D) - 1050 X 2100mm
11. Size of Door/Window Chaukath (Frame): 75 X 100mm

Steps for drawing Plan

- First imagine that the building (as shown in Fig.1) is cut by a horizontal plan at window sill level and after removing the top portion remaining portion is as shown in Fig. 2, the pictorial view.

- Then, the various elements of the building as shown in Fig.2 like the wall, widows, door, pillars, step etc. are projected on a horizontal plan (HP) keeping it below the above building as per the principle of first angle projection.
- The figure obtained from the above projection is the required **plan** as shown in Fig.3.
- The elements of the building, which are above the window sill level, are also shown in the plan as hidden line (i.e. by dashed line in state of continuous line) for example, the chajja.

Steps for drawing Elevation

- The pictorial view of the building from the front side is shown in Fig. 1
- Imagine that observer is standing in front of the above building and keeping the vertical plane (VP) behind it the front portion of the building is projected on to the VP.
- The figure so obtained on the VP is the **front elevation** as shown in Fig. 3.
- As per the principle of first angle projection the front elevation is drawn just above the plan.
- Thus, from the plan vertical lines from plinth wall, wall, pillar, etc. are projected. These lines are cut by horizontal lines at different height to get the elevation of different elements present in the front portion of the building.

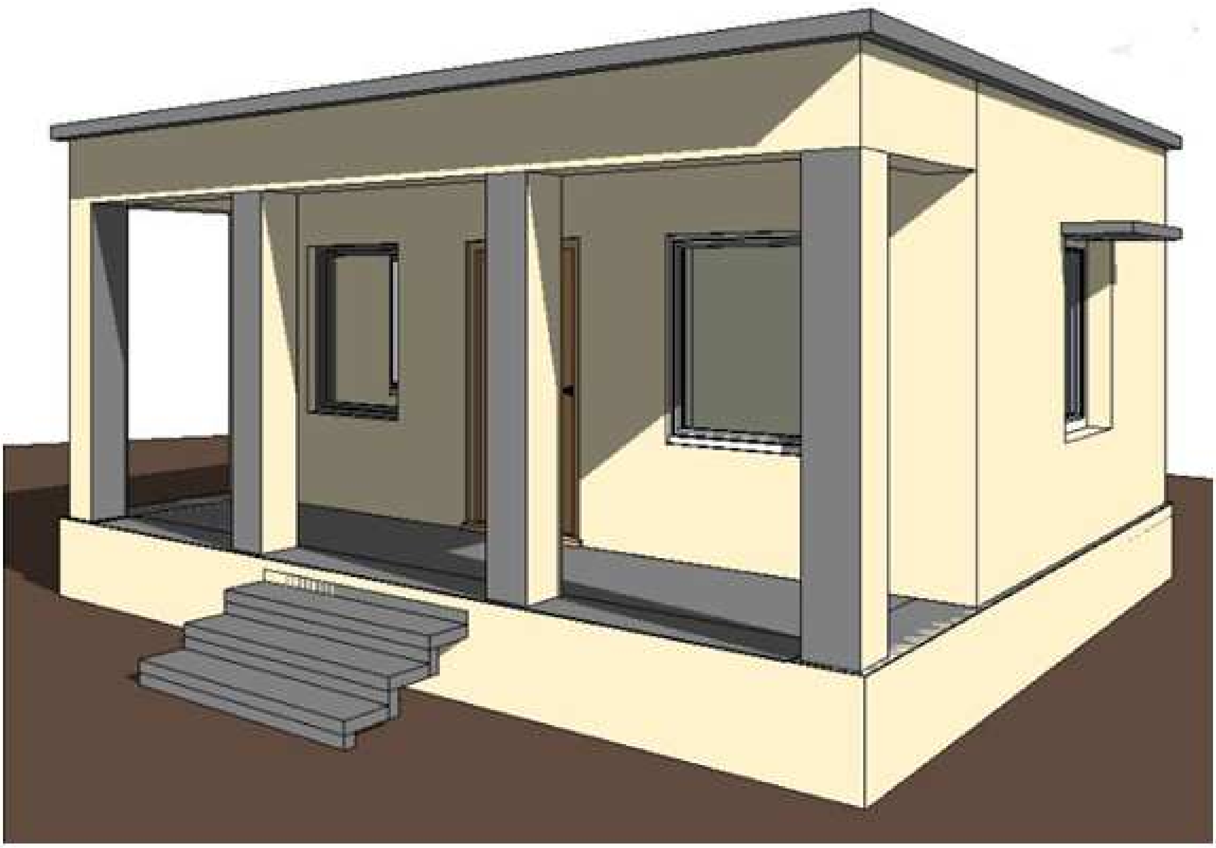


Fig.1 PICTORIAL VIEW OF THE GIVEN BUILDING

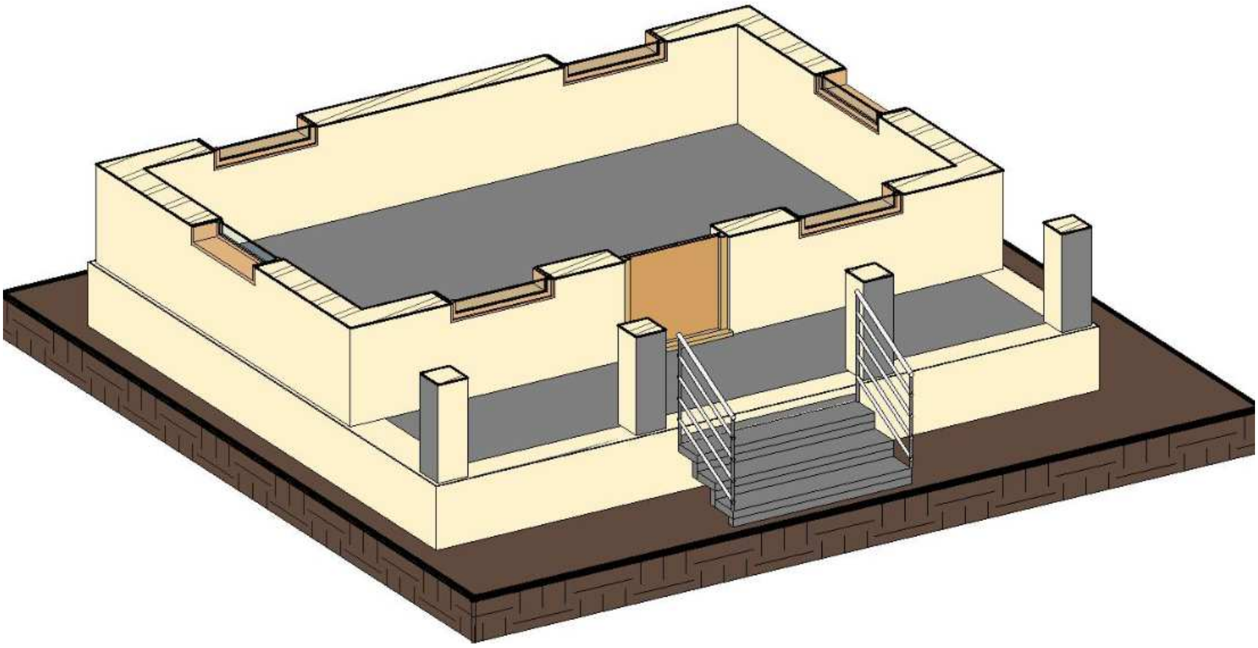
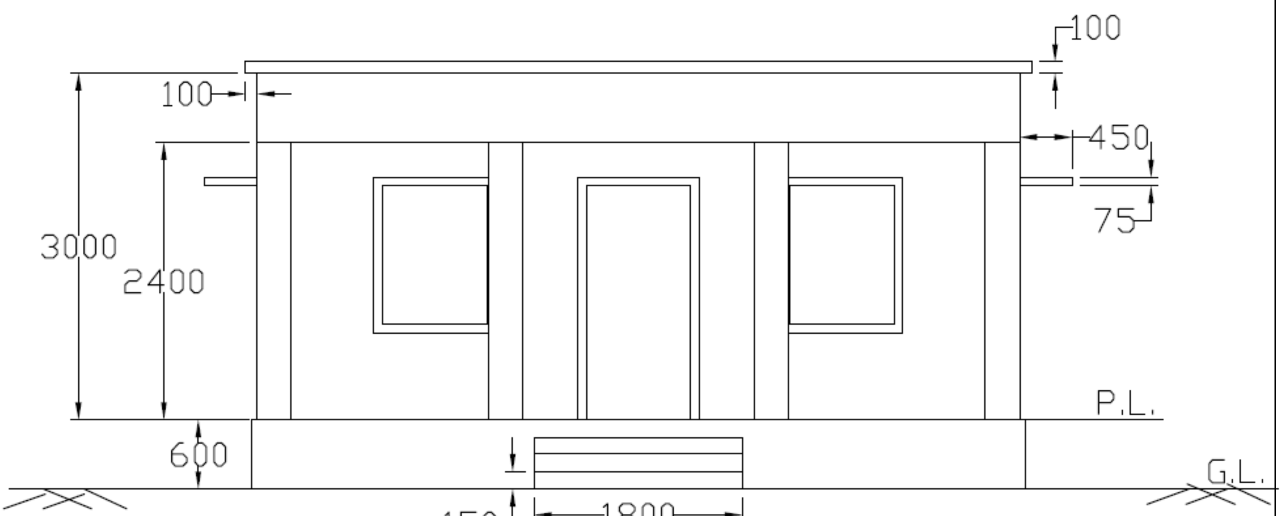
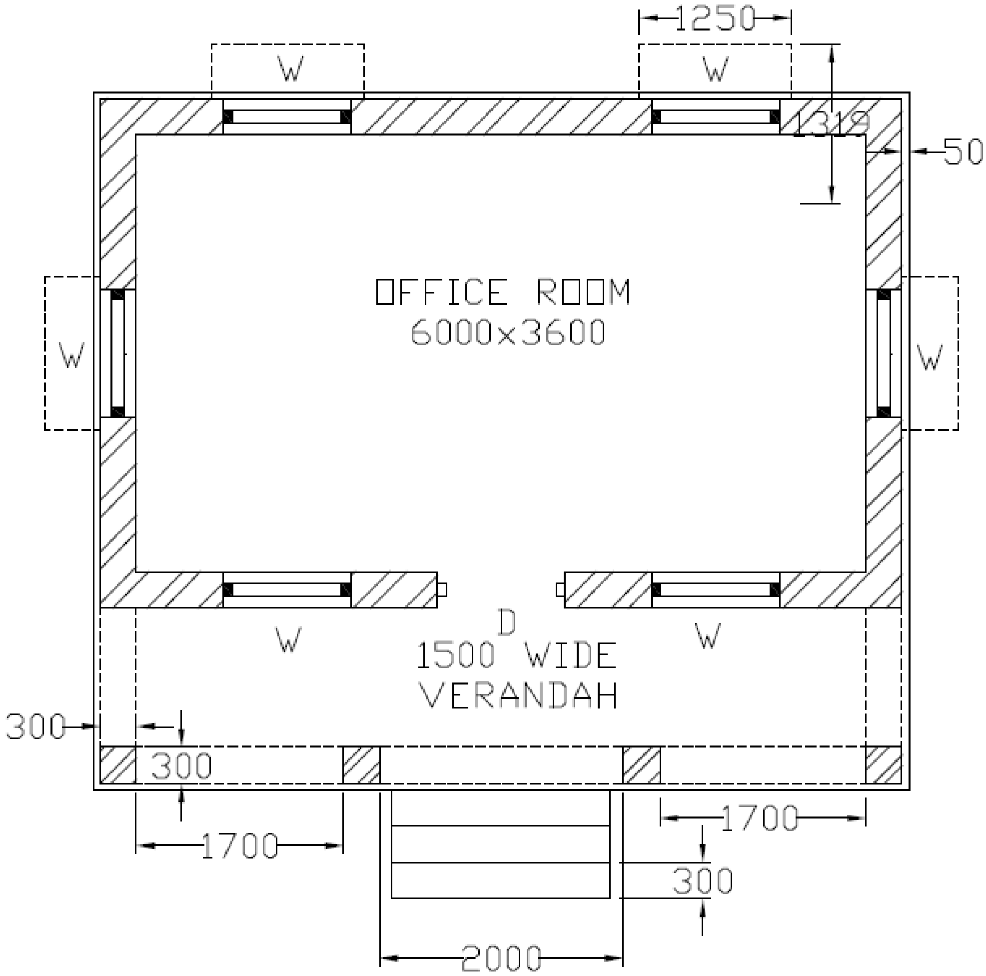


Fig 2. PICTORIAL VIEW OF THE REMAING PORTION OF THE BUILDING CUT BY A HORIZONTAL PLANE JUST ABOVE THE WINDOW SILL LEVEL



FRONT ELEVATION



PLAN

ALL DIMENSIONS ARE IN MM

Fig. 3 PLAN AND FRONT ELEVATION

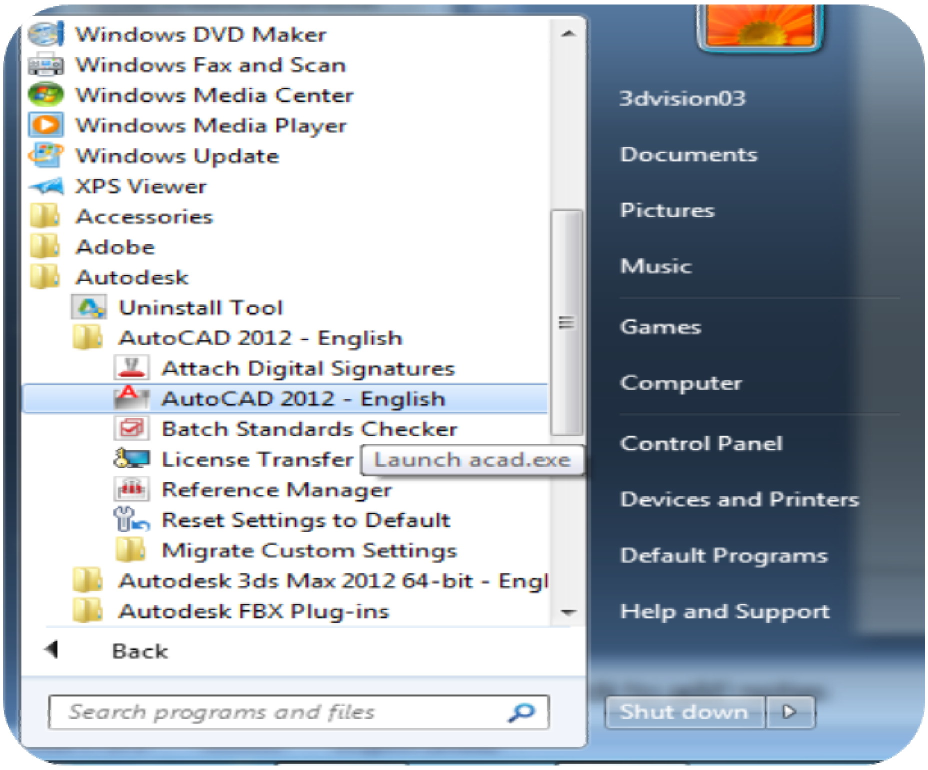
CHAPTER –9
PRACTICE ON AUTOCAD

INTRODUCTION

People have been using visual images to convey ideas for much longer than they have been using the written word, and this method continues even in today's technologically advanced world. Drawings are still used to communicate ideas effectively, but tools used to creat drawing have been changed. The advent of computer has created a new collection of tools / softwares for creation of drawings. One of these tools is Computer Added Design (CAD). As computers have become more advanced in power, speed, and affordability, CAD has been developed as well becoming easer to obtain and use. AutoCAD is one of such CAD software, which is widely used around the world for 2D and 3D computer-aided design and drafting of engineering drawings. It is developed and marketed by Autodesk. AutoCAD was first released in December 1982 by John Walker . It has been subsequently revised and up-graded. At presnt window based AutoCAD- 2012 is available in the market.

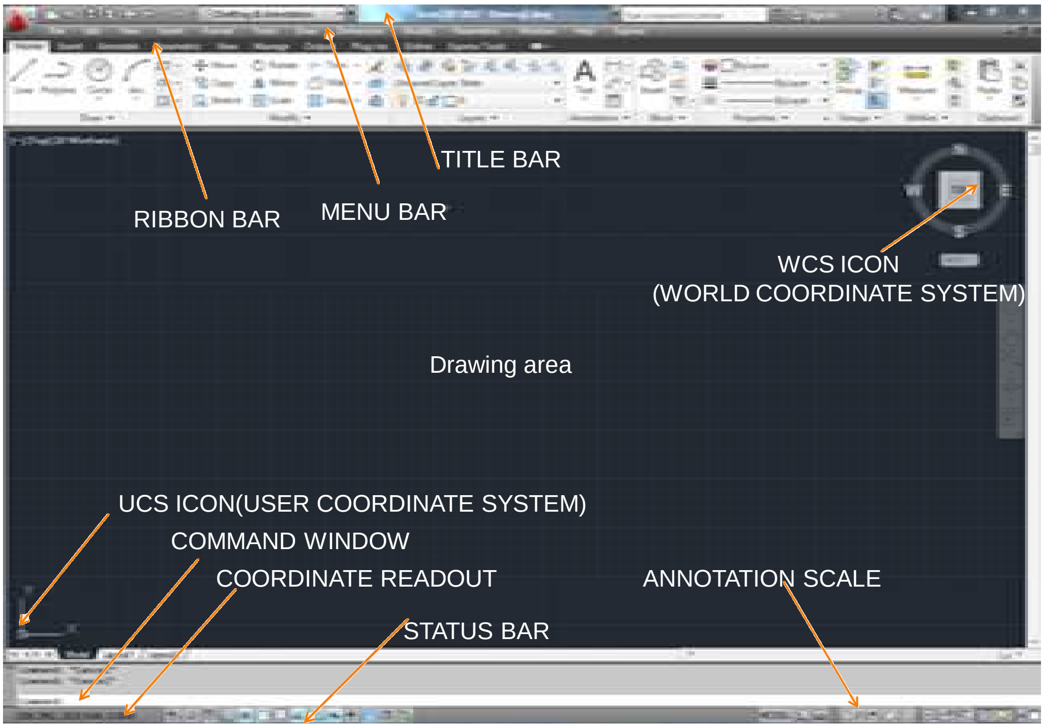
How to open AutoCAD ?

- Choose Start from the Windows program manager.
- Choose Programs - Autodesk- AutoCAD 2012.
- Click the AutoCAD 2012 for Windows icon.



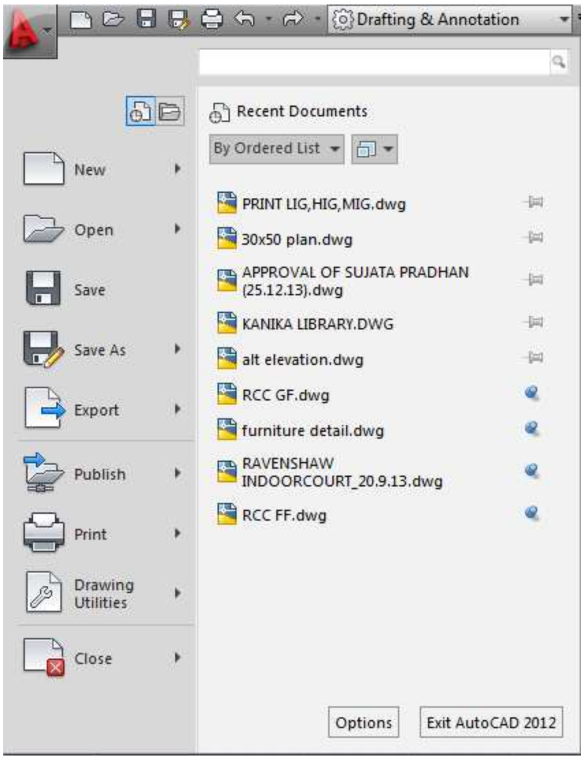
- OR
- Choose the AutoCAD 2012 icon from the desktop as shown below.

AutoCAD 2012 application window appears as shown below.



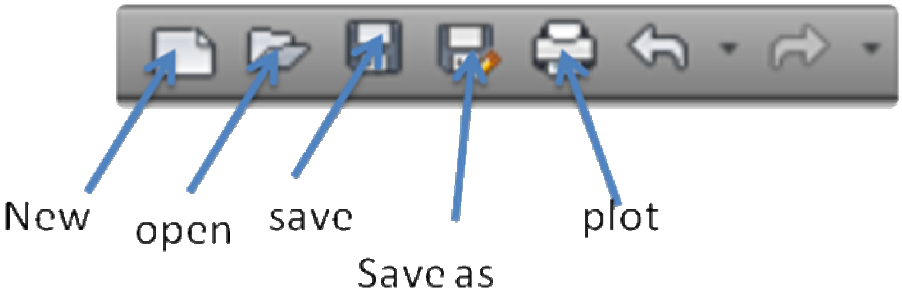
Menu browser

- Menu browser is represented by the letter A in red.
- It provides recently accessed documents.
- It consists of the file, open, save, save as, export, print, drawing utilities etc.



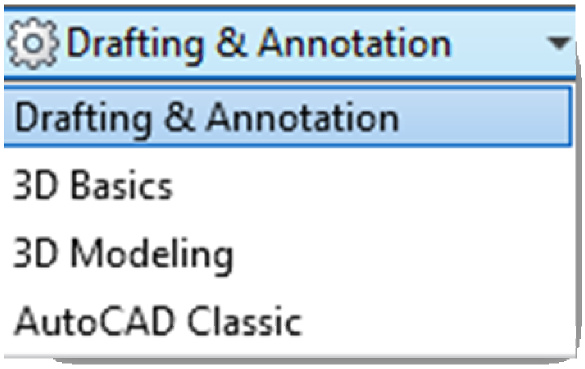
Quick access toolbar:

It includes commonly used options such as new, open, save, plot, undo, and redo etc.



Workspaces

- It is a collection of menus, toolbars,palettes & ribbon controls panel that are grouped and organized so that you can work in a custom, task-oriented drawing environment.
- Four types workspaces are defined in Autocad 2012.
- Those are
  - Drafting & Annotation
  - 3D Modeling
  - 3d basics
  - AutoCAD Classic

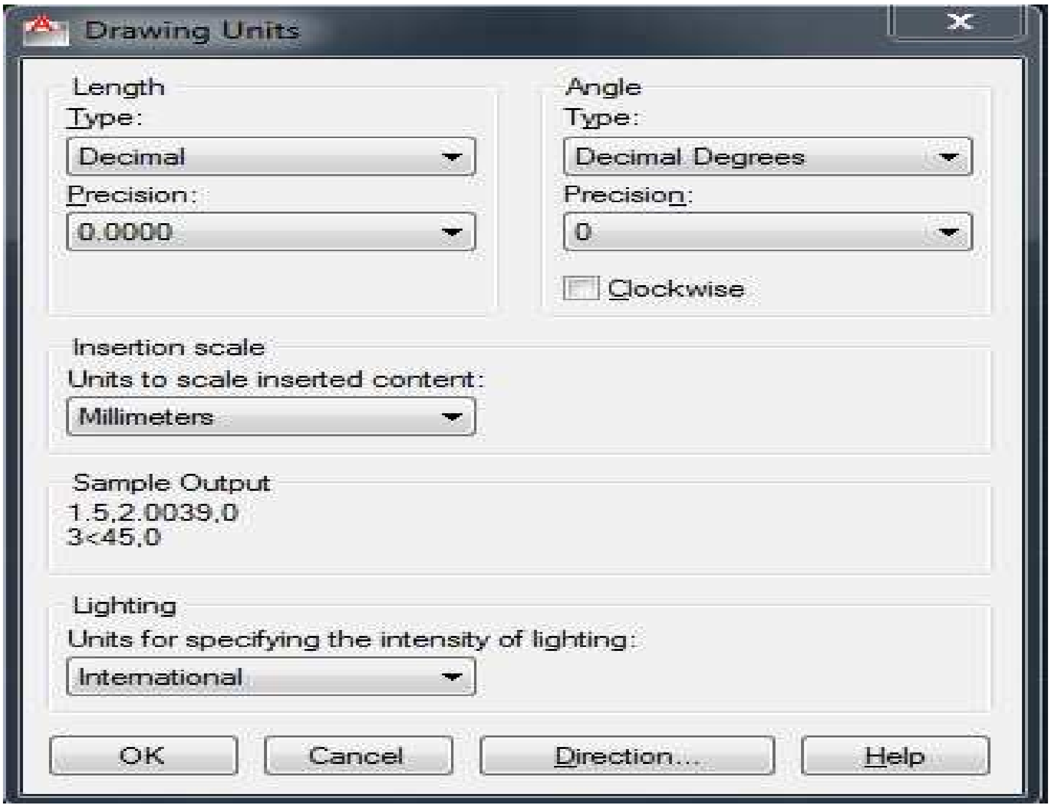


Function Keys

- F1- Help
- By pressing the F1 key actually enables the help. Further Pressing F1 while a tooltip or command is active displays Help for that command. Choosing the Help button in a dialog box displays Help for that dialog box.
- F2- Text Window
- By pressing the F2 key actually enables / activates the text window showing the previous command line activity (command history)
- F3- Osnap
- By pressing the F3 key actually enables / activates running object snap modes. Ways to access.
- F4- 3D Osnap
- F5- IsoPlane
- By pressing the F5 key activates the *Isoplane*. The isometric plane affects the cursor movement keys only when Snap mode is on and the snap style is Isometric. If the snap style is Isometric, Ortho mode uses the appropriate axis pair even if Snap mode is off. The current isometric plane also determines the orientation of isometric circles drawn by ELLIPSE.
- F6- Dynamic user Co-Ordinative system DUCS)
- By pressing the F6 key activates the Dynamic UCS on or off for 3D Modeling
- F7- Grid
- By pressing the F7 key activates the Grid command and either turns the GRID ON or GRID OFF
- F8- Ortho
- By pressing the F8 key activates the ORTHO command to ON or OFF. Activating the ORTHO helps us create lines in straight (linear) Vertical or Horizontal
- F9- Snap
- By pressing the F9 key activates the SNAP command to ON or OFF. Further it restricts cursor movement to specified intervals. (Snap to grid)
- F10- Polar
- By pressing the F10 key activates the Polar Tracking ON or OFF. Further Polar tracking restricts cursor movement to specified angles. Polar Snap restricts cursor movement to specified increments along a polar angle.

How to set the units

- Open a new drawing page in the autocad.
- Then units shortcut 'UN' Enter in the command window.
- Select the type of unit & precision under the length.
- For example we select the Decimal type unit & precision is 0.000 unit



How to set the Limits

- In command bar type limits then press Enter
- Reset Model space limits
  ON/ OFF/ <Lower left corner> <0,0 or current setting here>: Type in an absolute coordinate or press Enter to select default setting. NOTE: It is best to leave the Lower Left setting at the 0,0 .

  --Prompt: Upper right corner <12,9 or current setting here>: Type in a new absolute coordinate value for this corner and press Enter. NOTE: The default limits values in AutoCAD are 12 and 9. If you change to Metric units, the numbers change to the equivalent value in millimetres.

How to draw a line in AutoCAD?

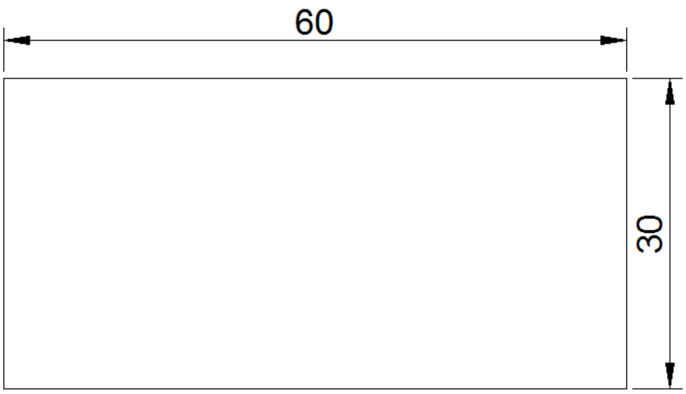
- LINE:- creates straight line segments
- Command: L press Enter
- Autocad will ask to specify the starting point of a line. Just one click on the screen or using coordinate axis with numerical values will specify the onset point.
- Then program will ask to end the line with another point.
- Then click somewhere on the screen or use coordinate axis with numerical values as well.
- For example :- A line draw in 25mm distance
- Command: L enter

- LINE Specify first point: 0
- Specify next point or [Undo]: 25

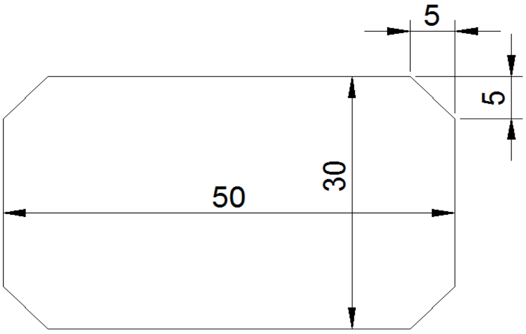
How to draw a rectangle in AutoCAD?

RECTANGLE:-The Rectangle command is used to draw a rectangle whose sides are vertical and horizontal. The Rectangle command also has a number of options like Chamfer, Elevation, Fillet, Thickness or Width.

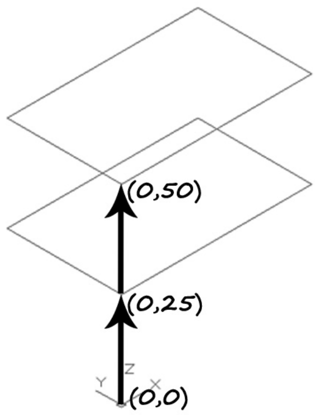
- Command: REC or rectang
  Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]: pick point
  Specify other corner point or [Area/Dimensions/Rotation]: @60,30



- Rectangle with Chamfer
- Command:rec _rectang
  Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]: C
  Specify first chamfer distance for rectangles <0.0000>: 5
  Specify second chamfer distance for rectangles <5.0000>: 5
  Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]: pick point
  Specify other corner point or [Area/Dimensions/Rotation]: @50,30



- <u>Rectangle with Elevation</u>
- Command: rec _rectang
  Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]: E
  Specify the elevation for rectangles <25.0000>: 25
  Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]: 0,0
  Specify other corner point or [Area/Dimensions/Rotation]: @50,30
  Command: RECTANGLE
  Current rectangle modes: Elevation=25.0000
  Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]: E
  Specify the elevation for rectangles <25.0000>: 50
  Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]: 0,0
  Specify other corner point or [Area/Dimensions/Rotation]: @50,30



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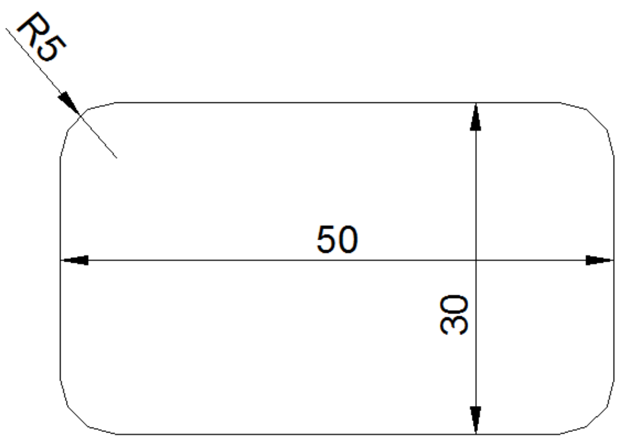
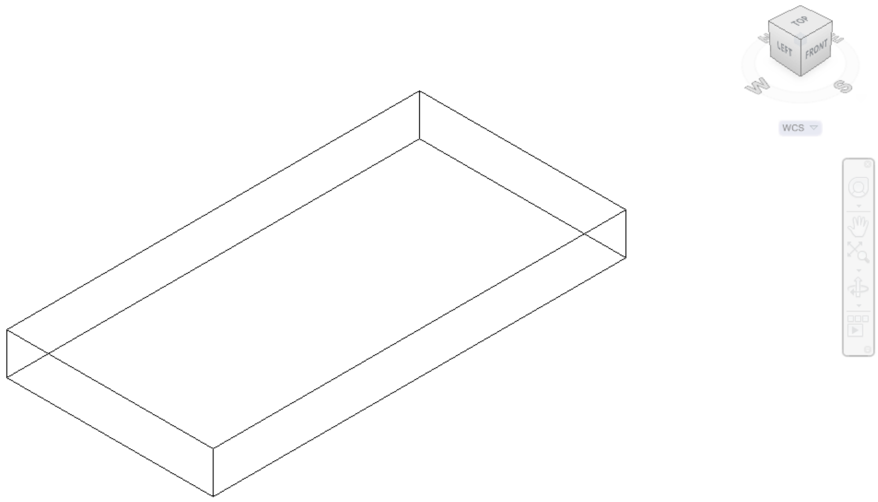
- <u>Rectangle with Fillet</u>
- Command:rec _rectang
  Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]: F
  Specify fillet radius for rectangles <5.0000>: 5
  Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]: 0,0 or pick point
  Specify other corner point or [Area/Dimensions/Rotation]: @50,30

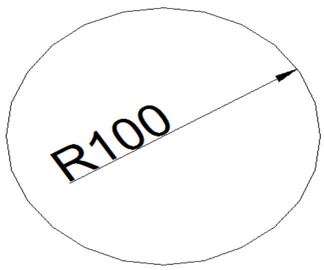


- Rectangle with Thickness
- Command:rec _rectang
  Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]: T
  Specify thickness for rectangles <0.0000>: 10
  Specify first corner point or [Chamfer/Elevation/Fillet/Thickness/Width]: 0,0
  Specify other corner point or [Area/Dimensions/Rotation]: @100,50



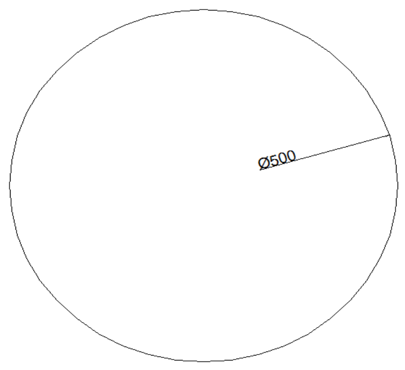
How to draw a circle in AutoCAD?

- Circle: create circles, various combinations of centre, radius, diameter, points on the circumference, and points on other objects.
- Keyboard Command: C
- CIRCLE command has 5 options for drawing circles.
- Circle by Centre - Radius
- Write C in command window and press Enter
  CIRCLE Specify centre point for circle or [3P/2P/Ttr (tan tan
- radius)]:pick a point
- Specify radius of circle or [Diameter]: 100

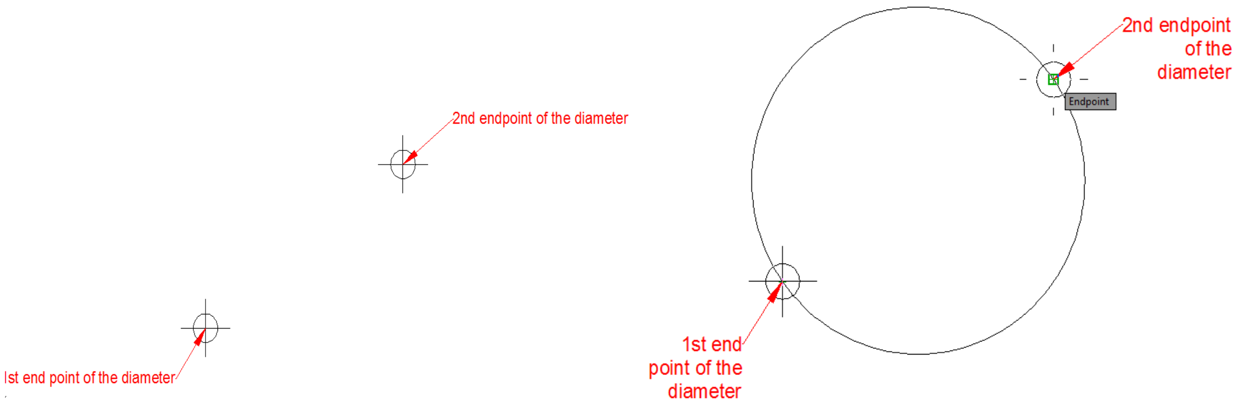


- Circle using Center - Diameter
- Command:C
  CIRCLE Specify centre point for circle or [3P/2P/Ttr (tan tan radius)]:

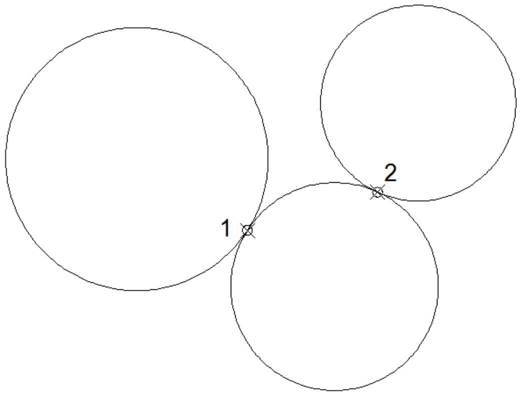
Specify radius of circle or [Diameter] <0.0>: D
Specify diameter of circle <0.0>: 500



- <u>Circle with the 2 Point</u>
- This method is simpler than the first one because it only requires to pick two points on the screen to make the circle. It needs the two endpoints of a diameter of the circle.
- Command: C and press Enter
  CIRCLE Specify centre point for circle or [3P/2P/Ttr (tan tan radius)]: 2p
  Specify first end point of circle's diameter:
- Specify second end point of circle's diameter.

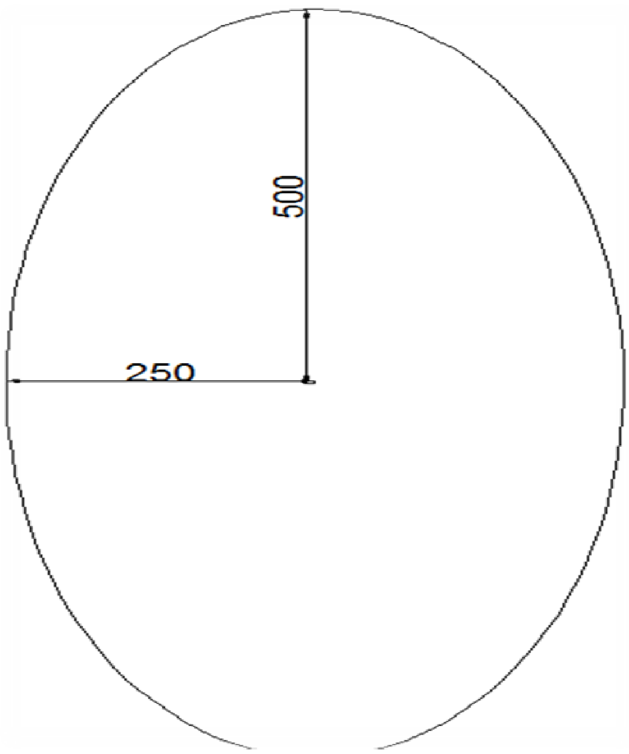


- <u>Drawing the Tangent Tangent Radius circle</u>
- Draws a circle with a specified radius tangent to two objects.
- Sometimes more than one circle matches the specified criteria. The program draws the circle of the specified radius whose tangent points are closest to the selected points.
- Command: C and press Enter
  CIRCLE Specify center point for circle or [3P/2P/Ttr (tan tan radius)]: t
    - Specify point on object for first tangent of circle:
    - Specify point on object for second tangent of circle:
    - Specify radius of circle <1413.0504>: 1500



How to draw an ellipse in AutoCAD?

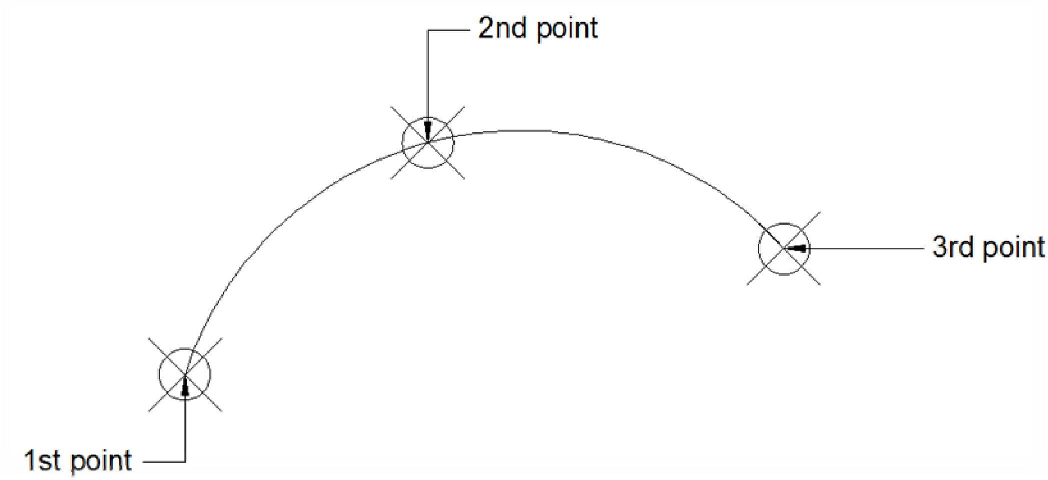
- Center ellipse
- Command: ellipse
- Specify axis endpoint of ellipse or [Arc/Center]: c
- Specify center of ellipse: pick point
- Specify endpoint of axis: <Ortho on> 250
- Specify distance to other axis or [Rotation]: 500



How to draw an arc in AutoCAD?

- 3 points Method
- Command: a and press Enter
- ARC Specify start point of arc or [Center]: pick 1st point
- Specify second point of arc or [Center/End]:

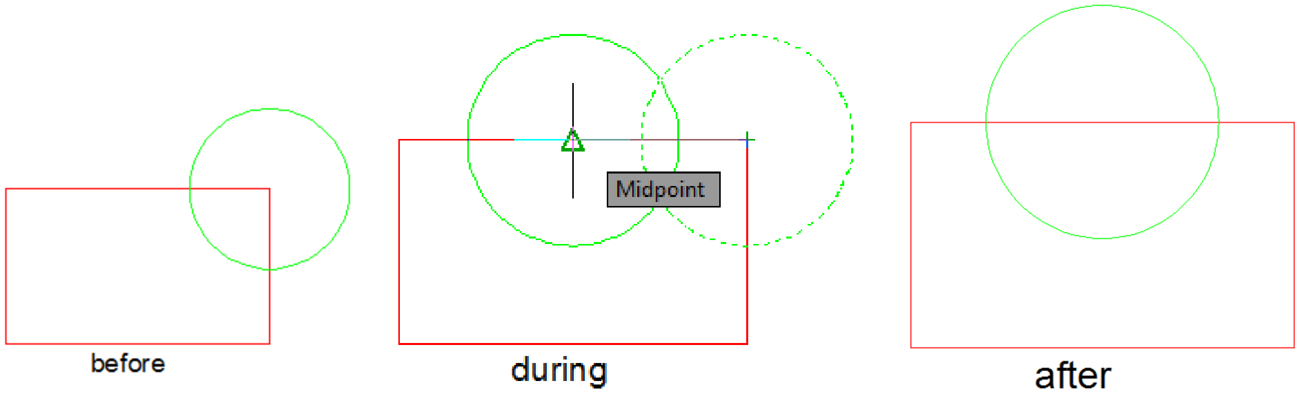
- Specify end point of arc:



EDIT COMMANDS and MODIFY COMMANS IN AutoCAD

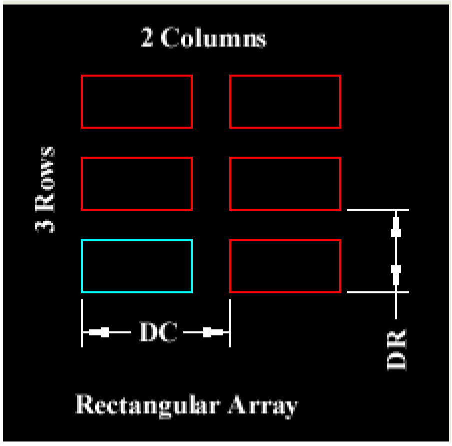
How to use move command AutoCAD?

- Move: This command helps in moving an object using the distance & direction specified by a base point followed by a second point.
- Keyboard Command: M
- Command Sequence
- Command: m _MOVE
- Select objects: Specify opposite corner: 1 found
- Select objects:
- Specify base point or [Displacement] <Displacement>:
- Specify second point or <use first point as displacement>:



How to use array command in AutoCAD?

- Array- The Array command makes multiple copies of selected objects in a rectangular matrix (columns and rows) or a polar (circular) pattern.
- keyboard Command: AR
- The Rectangular Array

- The illustration on the right shows the results of a rectangular array with two columns an three rows. The distance between rows is indicated with the dimension DR and between columns with DC.
- When creating rectangular arrays it is important to remember that new rows are created above the original object and new columns are created to the right of the original object.
- 

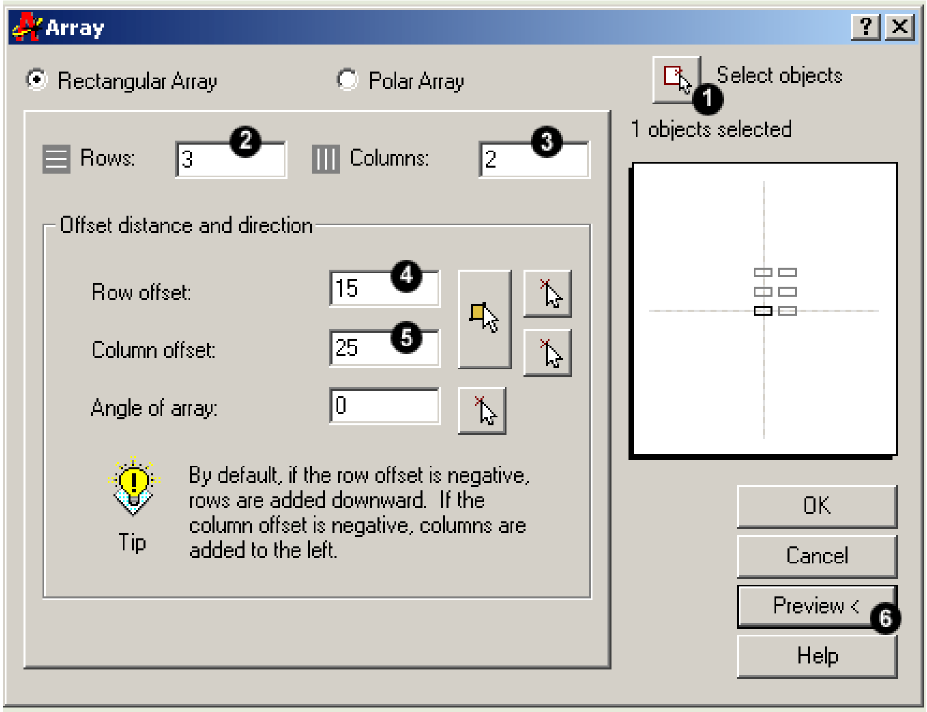
- Command: AR ARRAY
  Select objects: <SELECT THE RECTANGLE> 1 found
  Select objects: <ENTER>
  Enter array type [Rectangular/PAth/POlar] <Rectangular>: <ENTER>
  Select grip to edit array or [ASsociative/Base point/COUnt/Spacing/COLumns/Rows/Levels/eXit]<eXit>: R
  Enter the number of rows or [Expression] <2>: 3
  Specify the distance between rows or [Total/Expression] <0.7500>: 15

Type = Rectangular Associative = Yes

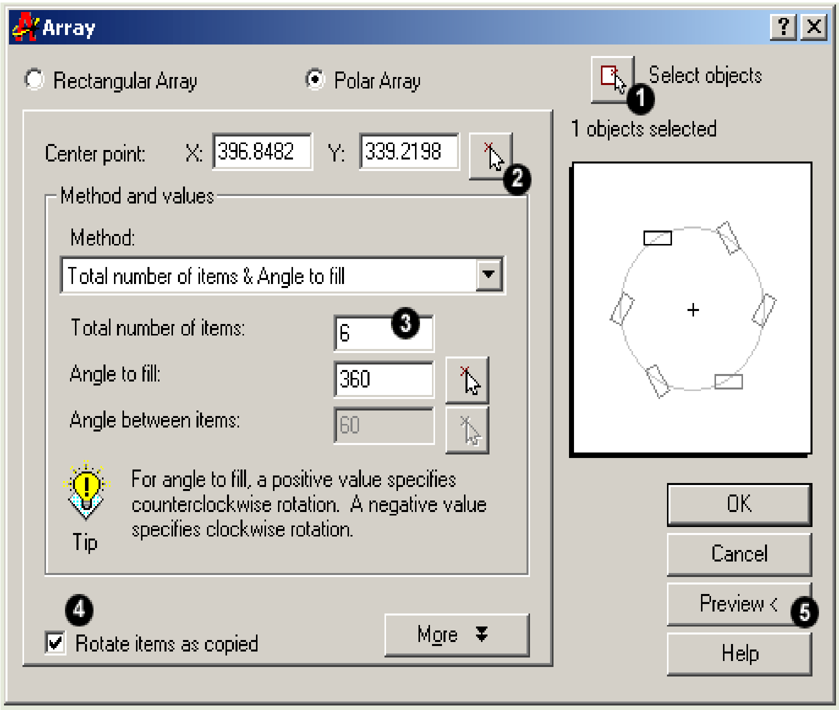
Select grip to edit array or [ASsociative/Base point/COUnt/Spacing/COLumns/Rows/Levels/eXit]<eXit>: COL
Enter the number of columns or [Expression] <4>: 2
Specify the distance between columns or [Total/Expression] <0.7500>: 25

Specify the incrementing elevation between rows or [Expresson] <0.0000>:<ENTER>

Select grip to edit array or [ASsociative/Base point/COUnt/Spacing/COLumns/Rows/Levels/eXit]<eXit>: <ENTER>

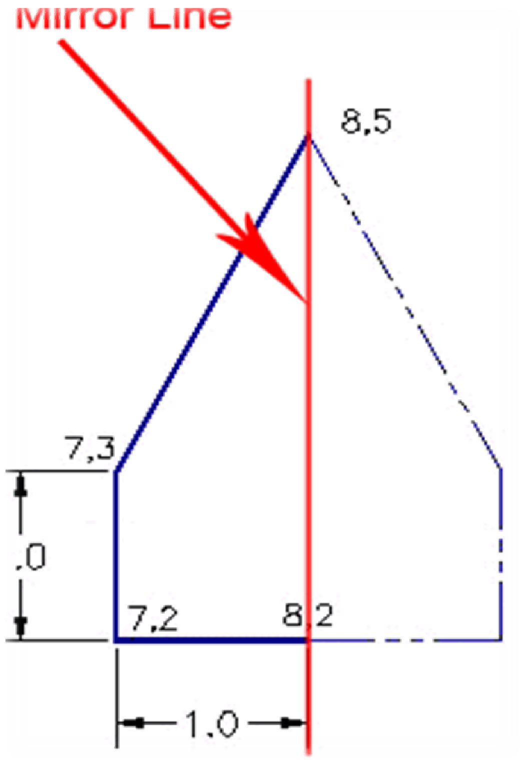


- Polar array-
- Command: ar ARRAY
- Select objects: 1 found
- Select objects:<ENTER>
- Enter array type [Rectangular/PAth/POlar] <Rectangular>: PO
- Type = Polar Associative = Yes
- Specify center point of array or [Base point/Axis of rotation]:C
- Enter number of items or [Angle between/Expression] <4>: 6
- Specify the angle to fill (+=ccw, -=cw) or [EXpression] <360>: 360
- Press Enter to accept or [ASsociative/Base point/Items/Angle between/Fill angle/ROWs/Levels/ROTate items/eXit]<eXit>:



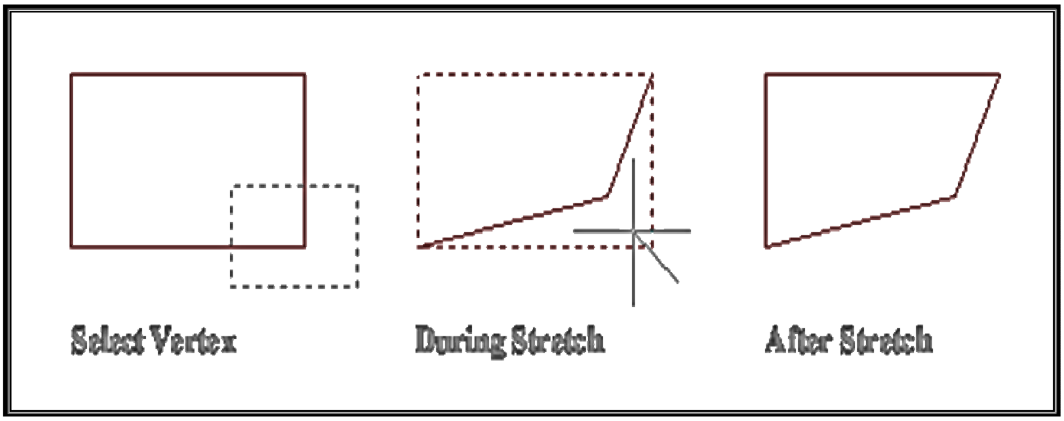
How to use mirror command in AutoCAD?

- Mirror: Creates symmetrical mirror images by flipping objects to a specific axis. The axis on which object is flipped is called a mirror line.
- Command: MI
- Command: MI _MIRROR
  Select objects: <SELECT THE 3 LINES> Specify opposite corner: 3 found
  Select objects: <ENTER>
  Specify first point of mirror line: <SELECT 8,5>
  Specify second point of mirror line: <SELECT 8,2>
  Erase source objects? [Yes/No] <N>: <ENTER>



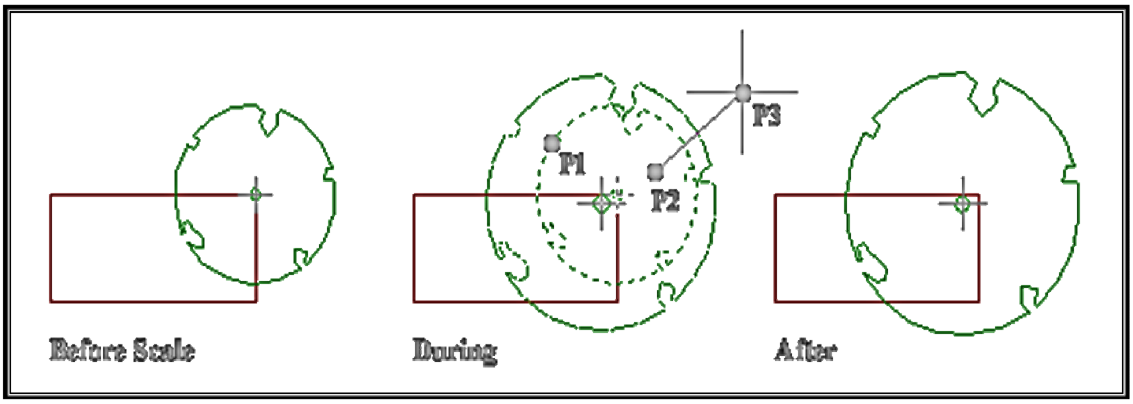
How to use stretch command in AutoCAD?

- Stretch:-Objects that are partially enclosed by a crossing window are stretched.
- Keyboard Command: S
- Command:S_STRETCH
  Select objects to stretch by crossing-window or crossing-polygon...
  Select objects: (pick first point of crossing window)
  Specify opposite corner: (pick second point of window)
  Select objects: (to end selection)
  Specify base point or displacement: (pick base point)
  Specify second point of displacement: (pick second point)



How to use scale command in AutoCAD?

- Scale:- To scale an object, specify a base point and a scale factor. A scale factor is greater than 1 enlarges the object. On the other hand the scale factor lies between 0&1 then the object shrinks.
- Keyboard Command: SC
- Command: SCALE
  Select objects: (pick objects to be scaled, P1)
  Select objects: (to end selection)
  Specify base point: (pick base point, P2)
  Specify scale factor or [Reference]: (pick second point, P3 or enter scale factor)

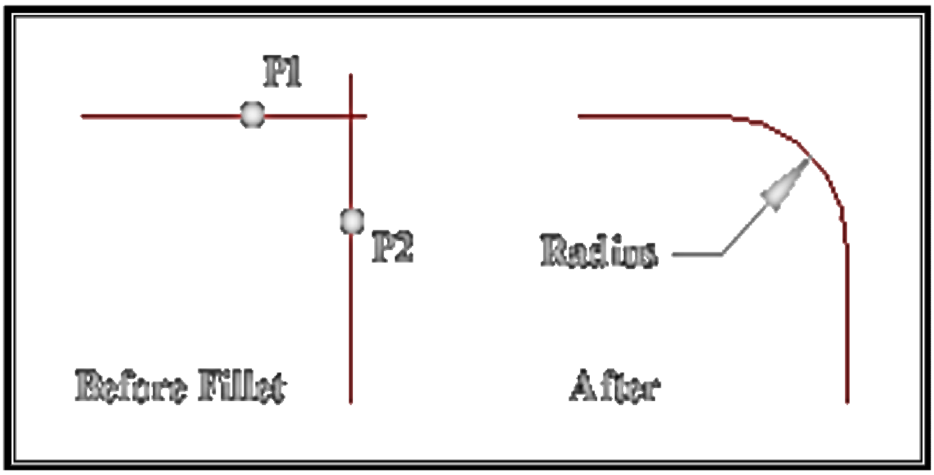


How to use chamfer command in AutoCAD?

- Chamfer:-a chamfer options connects two objects with an angled line. The chamfered corners help to convert sharp corners into uniform angled corners.
- Keyboard Command: CHA
- Command: CHa _CHAMFER
- (TRIM mode) Current chamfer Dist1 = 25.0000, Dist2 = 25.0000
- Select first line or [Undo/Polyline/Distance/Angle/Trim/mEthod/Multiple]: d
- Specify first chamfer distance <25.0000>: 50 Specify second chamfer distance <50.0000>: 50
- Select first line or [Undo/Polyline/Distance/Angle/Trim/mEthod/Multiple]:
- Select second line or shift-select to apply corner or [Distance/Angle/Method]:

How to use fillet command in AutoCAD?

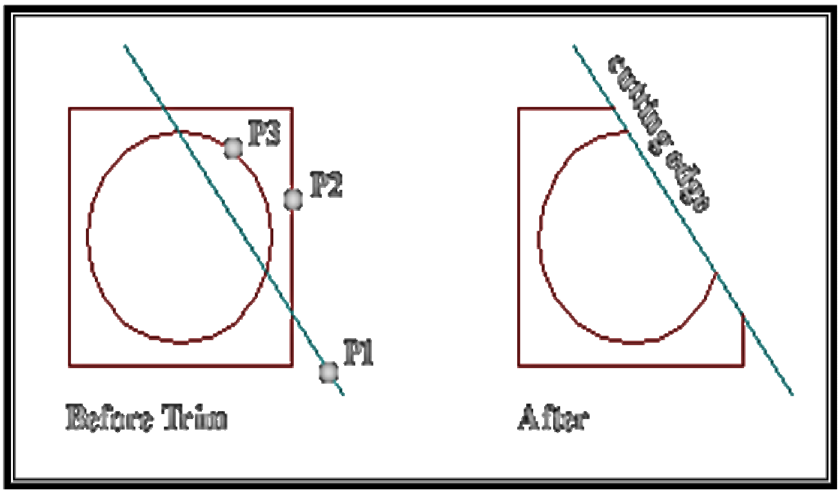
- Fillet: A fillet connects two objects with an arc that tangent to the objects & has a specified radius. Filleting produces a rounded corner effect.
- Keyboard Command: F
- Command: F_ FILLET
  Current settings: Mode = TRIM, Radius = 10.0000
  Select first object or [Polyline/Radius/Trim]: R
  Specify fillet radius <10.000>: 25
  Select first object or [Polyline/Radius/Trim]: (pick P1)
  Select second object : (pick P2)



How to use trim command in AutoCAD?

- Trim:- The Trim command can be used to trim a part of an object. In order to trim an object one must draw a second object which forms the "cutting edge". Cutting edges can be lines, xlines, rays, polylines, circles, arcs or ellipses. Blocks and text cannot be trimmed or used as cutting edges.
- The command's alias. Command: Tr
- Command: TRIM
  Current settings: Projection=UCS Edge=None
  Select cutting edges ...
  Select objects: (select the cutting edge, P1)
  Select objects: (to end cutting edge selection)
  Select object to trim or shift-select to extend or [Project/Edge/Undo]:(pick the part of the square which you want to trim, P2)

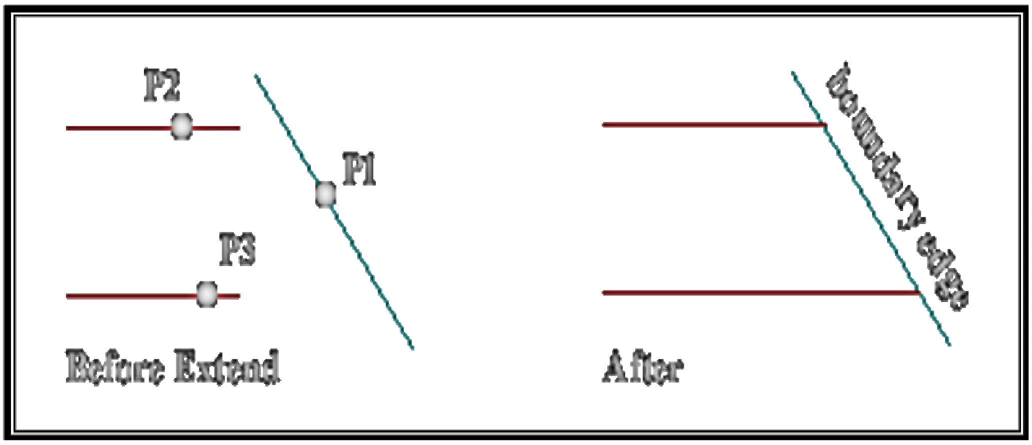
Select object to trim or shift-select to extend or [Project/Edge/Undo]: (pick the circle, P3)
Select object to trim or shift-select to extend or [Project/Edge/Undo]: (to end)



How to use extend command in AutoCAD?

- Extend:-This command extends a line, polyline or arc to meet another drawing object (known as the boundary edge)
- Keyboard Command: Ex
- Command: EXTEND

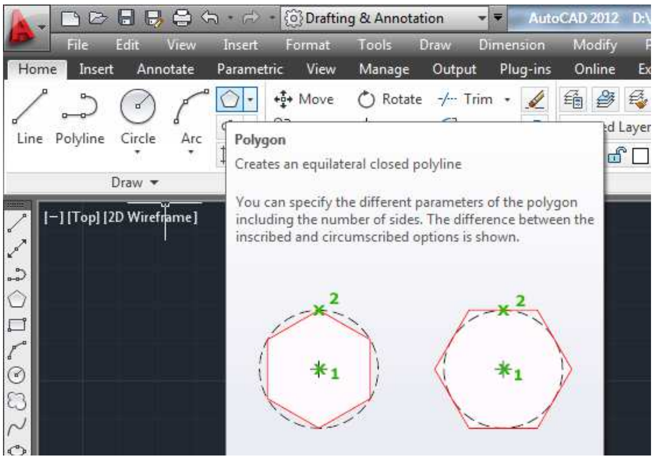
  Current settings: Projection=UCS Edge=None
  Select boundary edges ...
  Select objects: (select the boundary edge, P1)
  Select objects: (to end boundary edge selection)
  Select object to extend or shift-select to trim or [Project/Edge/Undo]: (pick the object which you want to be extended, P2)
  Select object to extend or shift-select to trim or [Project/Edge/Undo]: (pick another object which you want to be extended, P3)
  Select object to extend or shift-select to trim or [Project/Edge/Undo]: (to end)

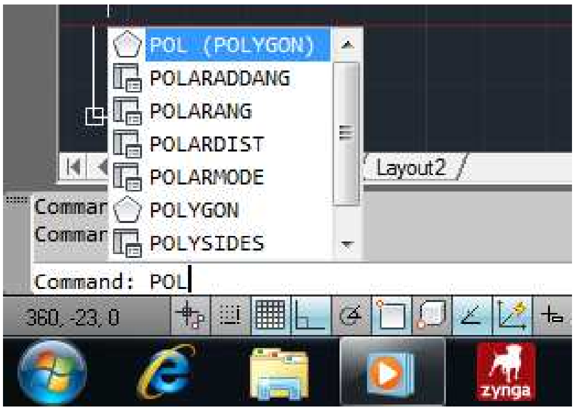


Problem 1: Draw the projections of a hexagonal prism of side of base 25mm and height 50mm resting with its base on H.P. such that one of its rectangular faces is perpendicular to V.P.

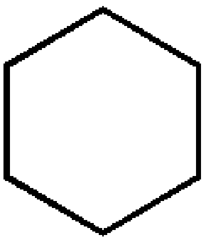
PLAN

1. Select polygon in ribbon bar
   or
   Write pol in command window and press Enter



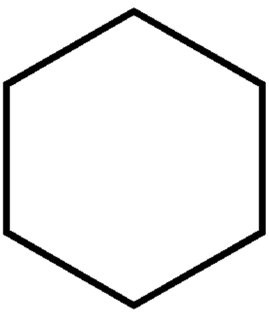


2. POLYGON ENTER NUMBER OF SIDES <4>: 6
3. SPECIFY CENTRE OF POLYGON OR [EDGE] : E SPECIFY FIRST ENDPOINT OF EDGE: SPECIFY SECOND ENDPOINT OF EDGE: 25

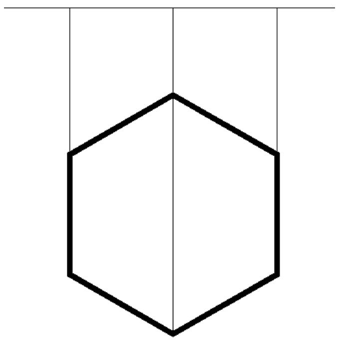


ELEVATION

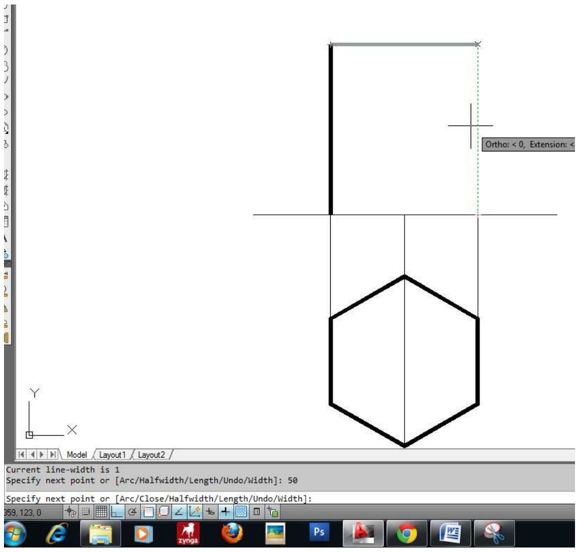
1. Create a horizontal line.



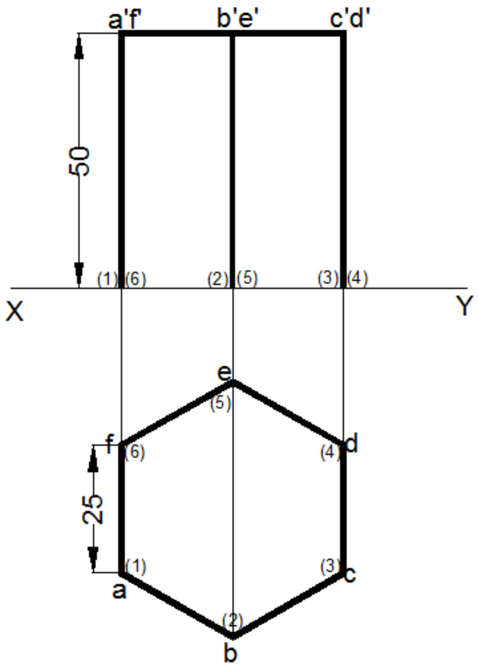
2. Then use Line command to draw perpendicular to horizontal line



3. COMMAND: PLINE
   SPECIFY START POINT:
   CURRENT LINE-WIDTH IS 1
   SPECIFY NEXT POINT OR [ARC/HALFWIDTH/LENGTH/UNDO/WIDTH]: 50



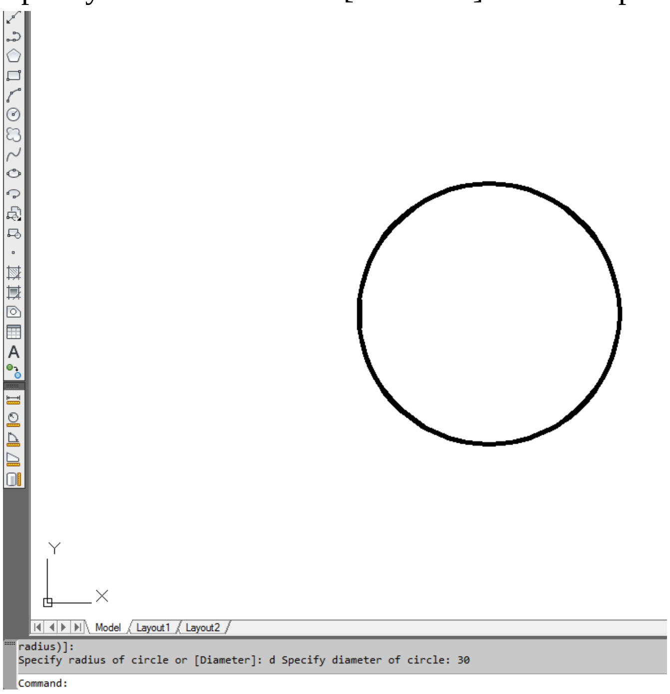
4. Then text & dimension commands are used to obtain the required plan and elevation as shown below.



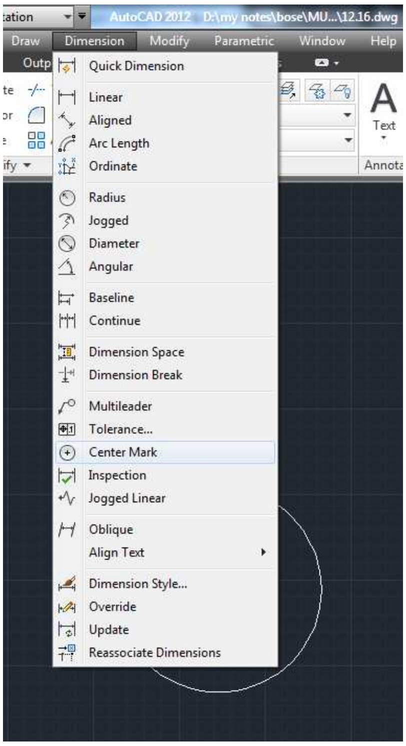
Problem 2: Draw the projection of a cylinder of base 30mm diameter and axis 50mm long resting with its base on H.P. and axis 25 mm in front of V.P.

PLAN

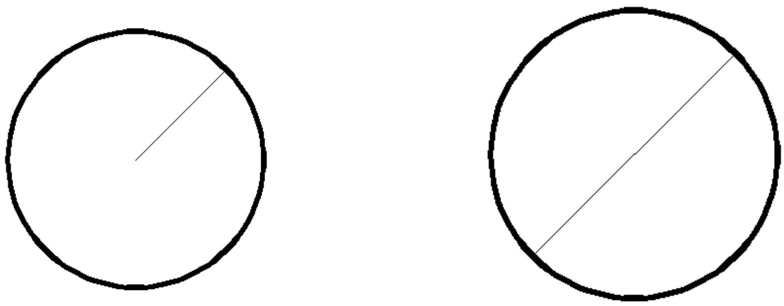
4. Command: C or CIRCLE
5. Specify center point for circle or [3P/2P/Ttr (tan tan radius)]:
   Specify radius of circle or [Diameter] <15>: d Specify diameter of circle <30>: 30



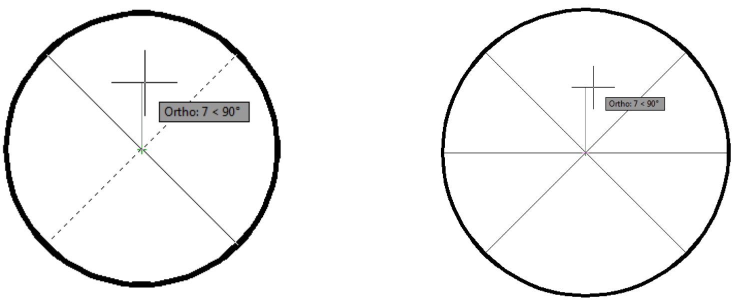
6. Then go to dimension in menu bar & click centre mark



7. Command: l
8. LINE Specify first point:
   Specify next point or [Undo]: @15<45
   & extend the line

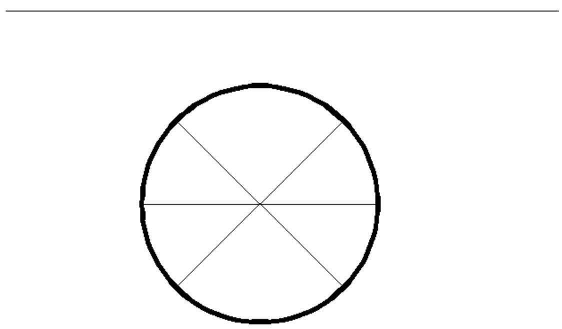


9. Mirror the angle line & create perpendicular line horizontal & vertical

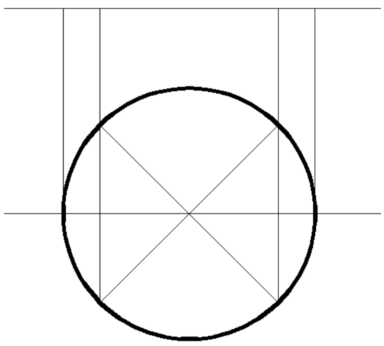


ELEVATION

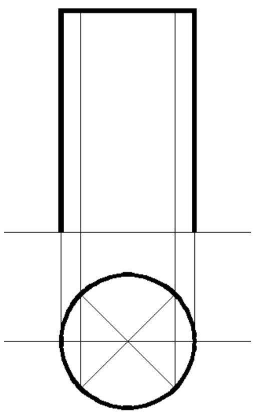
5. Create a line of horizontal



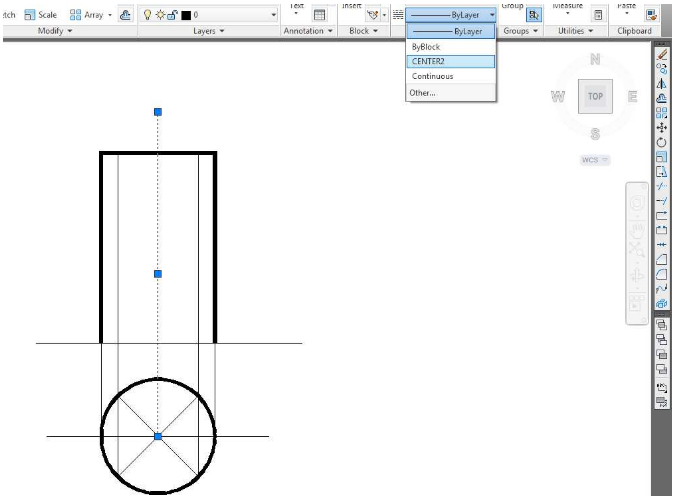
6. Then use command L and press ENTER
7. Draw perpendiculars from the points on circle to horizontal line



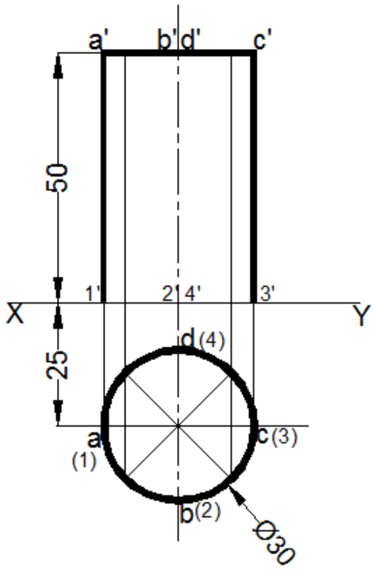
8. COMMAND: PLINE
   SPECIFY START POINT:
   CURRENT LINE-WIDTH IS 1
   SPECIFY NEXT POINT OR [ARC/HALFWIDTH/LENGTH/UNDO/WIDTH]: 50



9. Create a centre line & change the centre line type



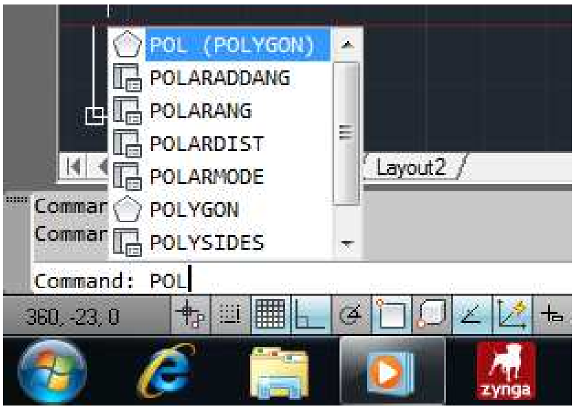
10. Then text & dimension commands are used to obtain the required plan and elevation as shown below.



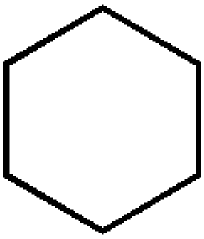
Problem 3: Draw the projections of pentagonal pyramid side of base 30mm and height 60mm resting with its base on H. P. such that one of the edge of the base is perpendicular to V.P.

PLAN

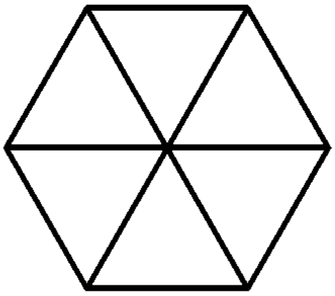
1. Select polygon in ribbon bar
   or
   Write pol in command window and press Enter



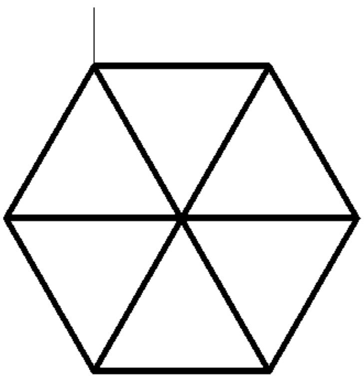
2. POLYGON ENTER NUMBER OF SIDES <4>: 6
3. SPECIFY CENTRE OF POLYGON OR [EDGE] : E SPECIFY FIRST ENDPOINT OF EDGE:
   SPECIFY SECOND ENDPOINT OF EDGE: 30



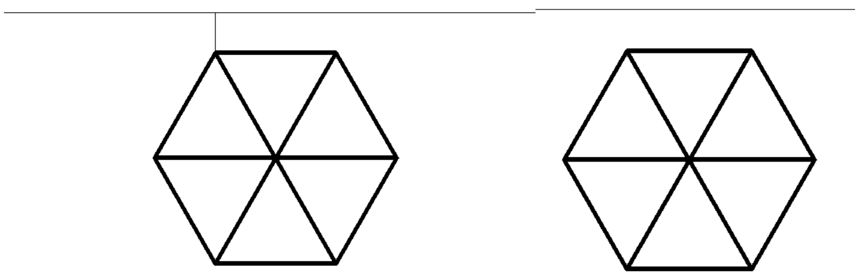
4. All points joins in endpoint to end point in Line command



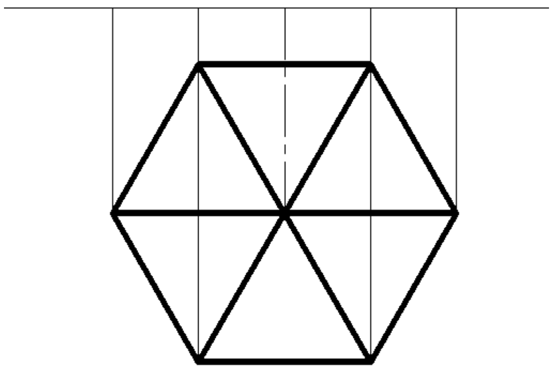
5. Command: l
   LINE Specify first point:
   Specify next point or [Undo]: 10



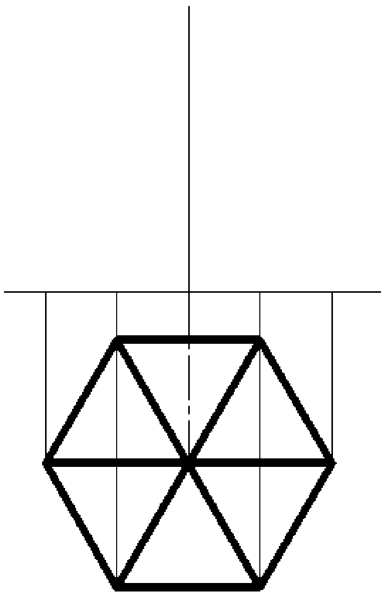
6. Create a line & delete the perpendicular line



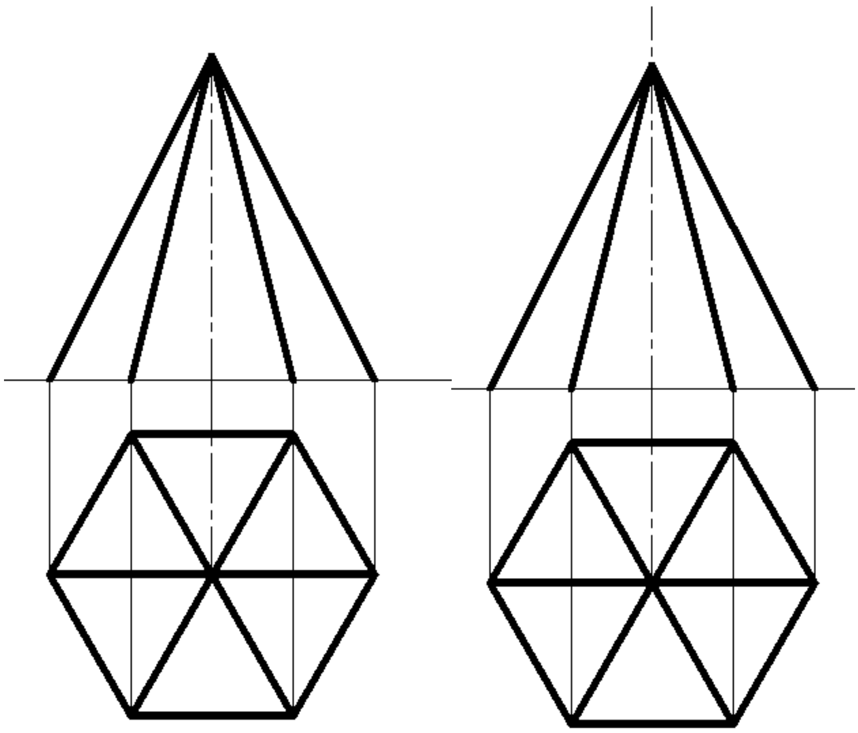
7. Then use command L and press ENTER
   Draw perpendiculars from the points on circle to horizontal line



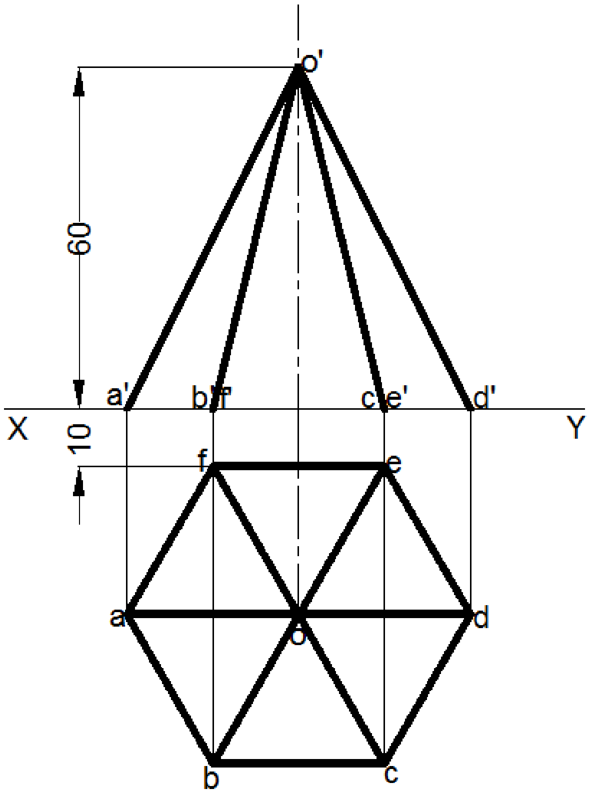
8. Command: l LINE Specify first point:
   Specify next point or [Undo]: 60



9. Join the line end point to end point & stretch the centre line



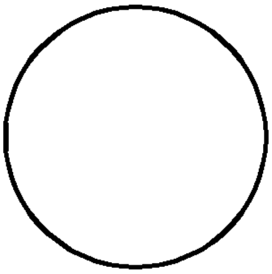
10. Then text & dimension commands are used to obtain the required plan and elevation as shown below.



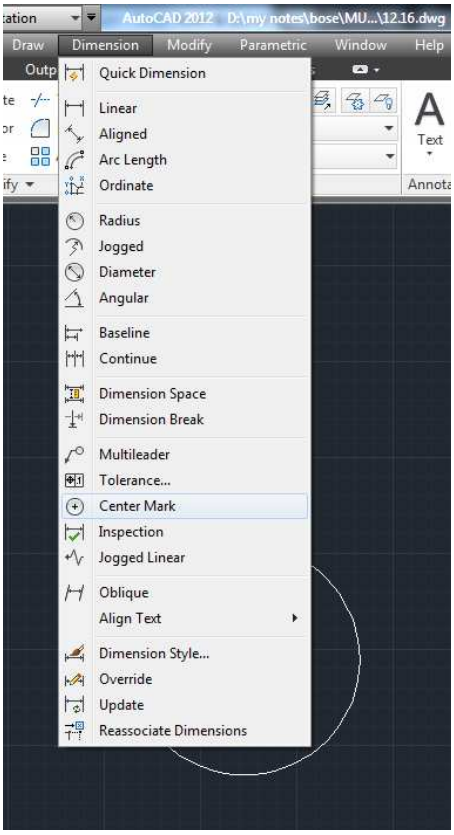
Problem 4: Draw the projection of a right circular cone of base 40mm and height 60mm when resting with its base on H.P.

PLAN

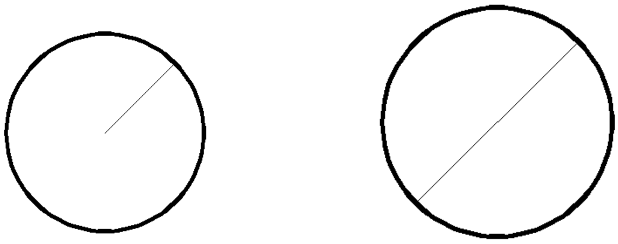
10. Command: C or CIRCLE
    Specify center point for circle or [3P/2P/Ttr (tan tan radius)]:
    Specify radius of circle or [Diameter] <15>: d Specify diameter of circle <30>: 40



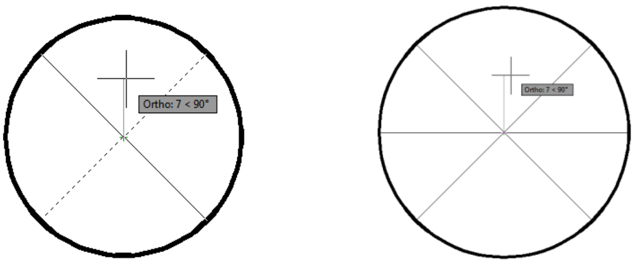
11. Then go to dimension in menu bar & click centre mark



12. Command: l LINE Specify first point:
    Specify next point or [Undo]: @15<45
    & extend the line

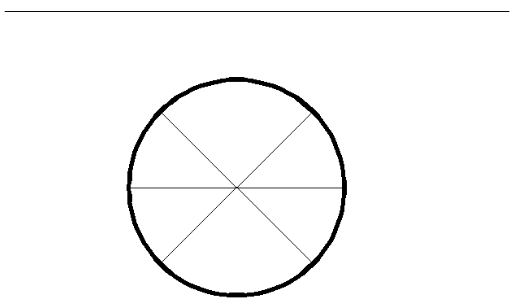


13. Mirror the angle line & create perpendicular line horizontal & vertical

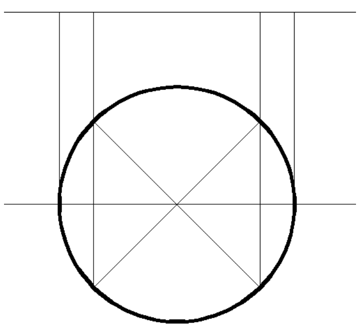


ELEVATION

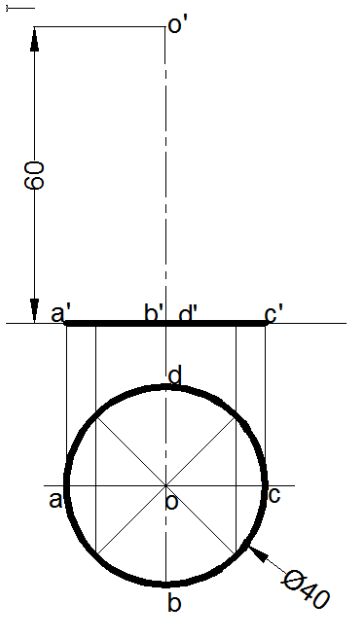
11. CREATE A LINE OF HORIZONTAL



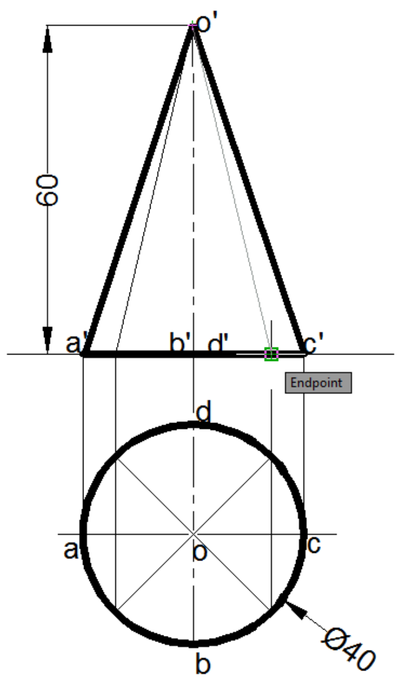
12. THEN L ENTER POINT TO PERPENDICULAR TO HORIZONTAL LINE



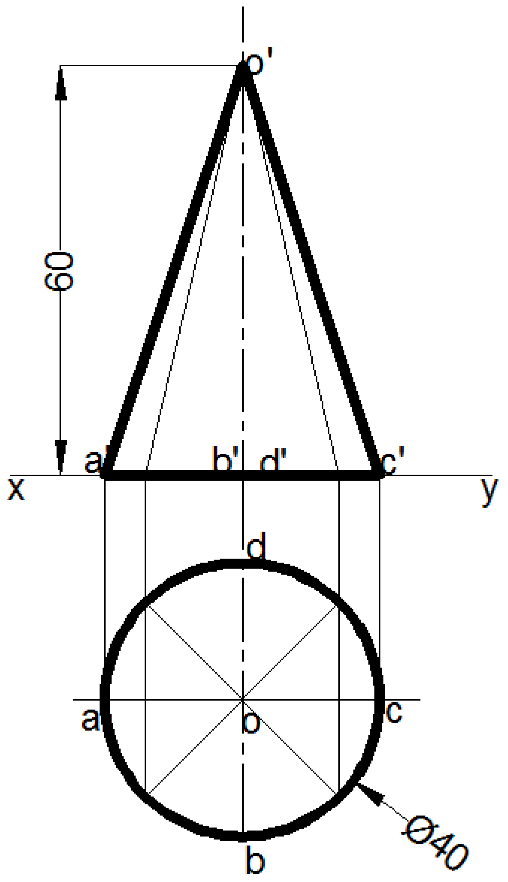
13. Command: l LINE Specify first point:
    Specify next point or [Undo]: 60



14. Join the line end point to end point



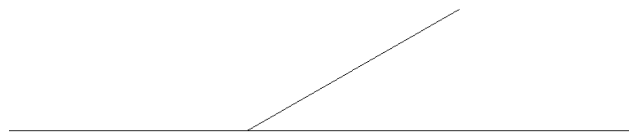
10. Then text & dimension commands are used to obtain the required plan and elevation as shown below.



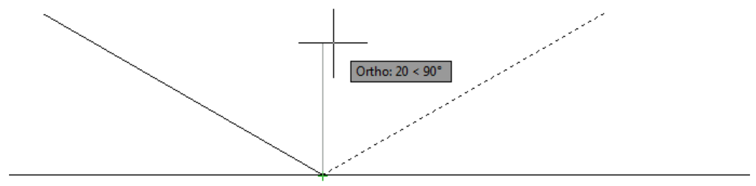
Problem 5: Draw the isometric view of a hexagonal prism side of base 25mm and height 60mm resting on the ground in vertical position and one of the side of the hexagon is parallel to V.P.

1. Command: l LINE
   Specify first point:

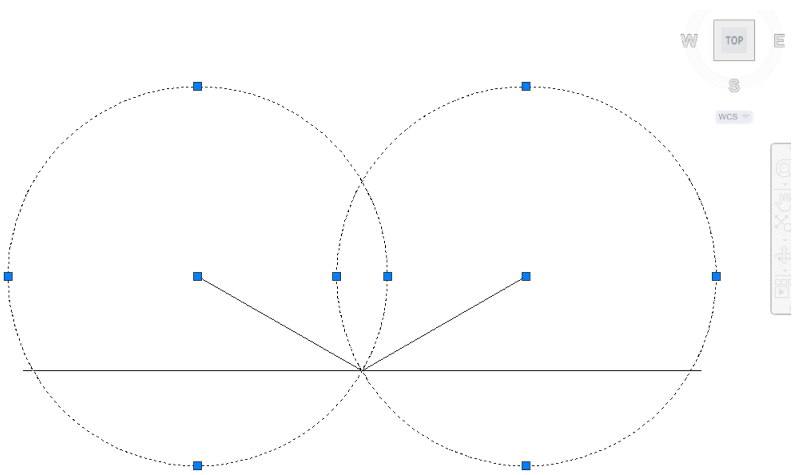
2. Command: l
   LINE Specify first point:
   Specify next point or [Undo]: @50<30



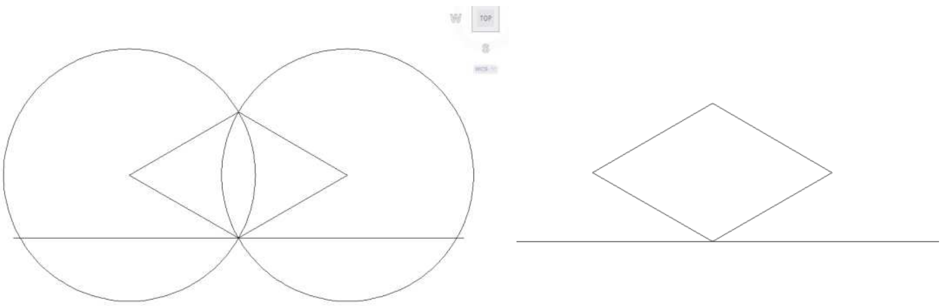
3. Mirror to opposite side



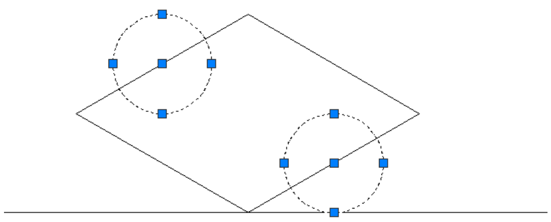
4. Command: c CIRCLE
   Specify center point for circle or [3P/2P/Ttr (tan tan radius)]:
   Specify radius of circle or [Diameter] <25>: 50



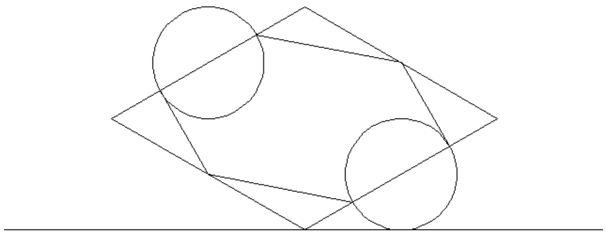
5. Then join the lines circles intersection point & delete the circle

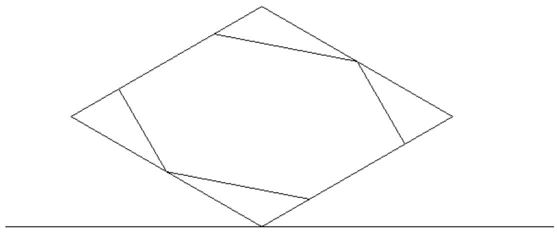


6. Draw a circle in the midpoint of line
   Command: CIRCLE Specify center point for circle or [3P/2P/Ttr (tan tan radius)]:
   Specify radius of circle or [Diameter] <25>: d Specify diameter of circle <50>: 25

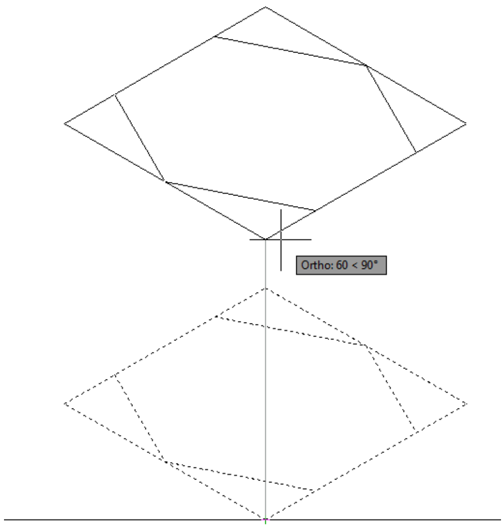


7. Join the line & delete the circle

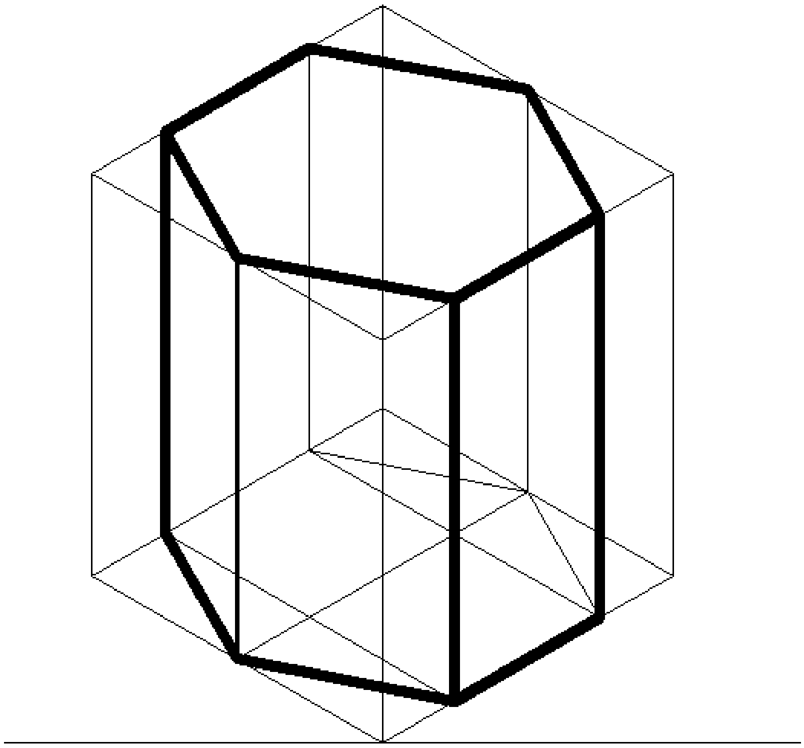




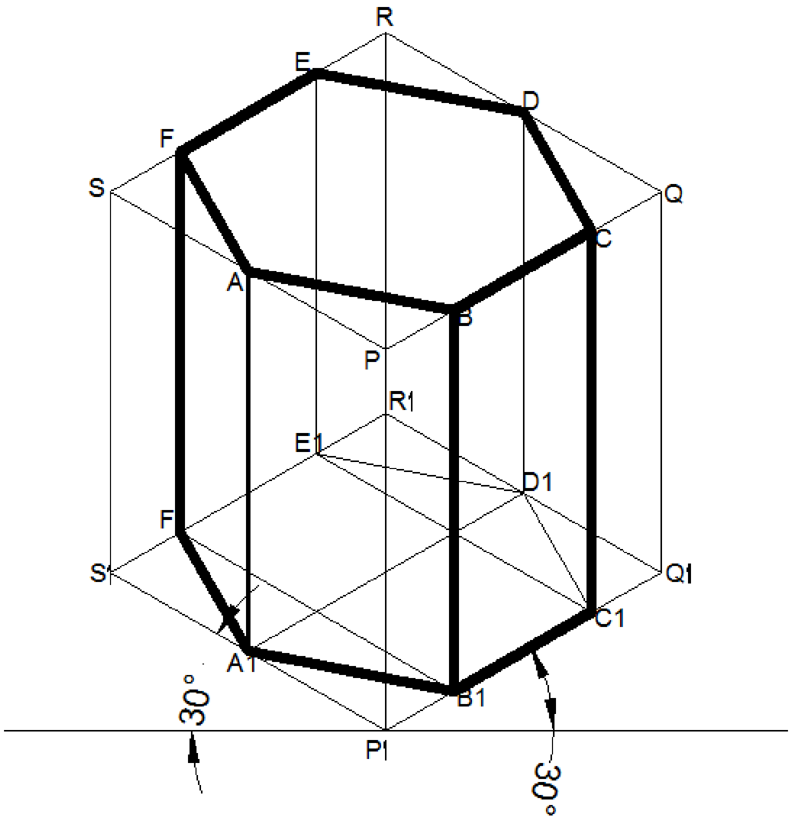
8. Then copy the object from perpendicular distance 60



9. Then join the line endpoint to endpoint



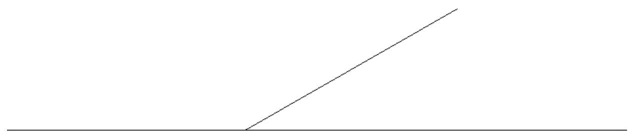
10. Then text & dimension commands are used to obtain the required plan and elevation as shown below.



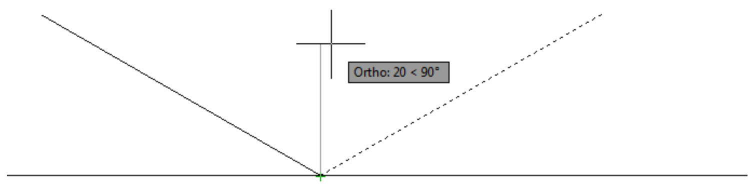
Problem 6: Draw the isometric view of a hexagonal pyramid of side 30mm and height 75mm, when it is resting on H. P. such that an edge of base is parallel to V.P.

1. Command: l LINE Specify first point:

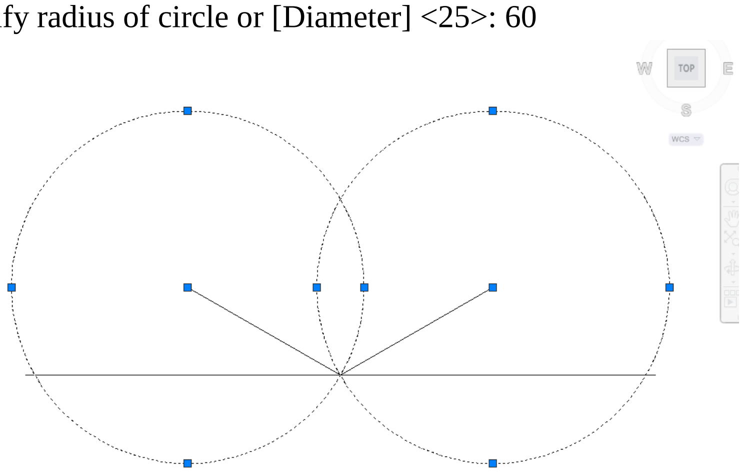
2. Command: l LINE Specify first point:
   Specify next point or [Undo]: @60<30



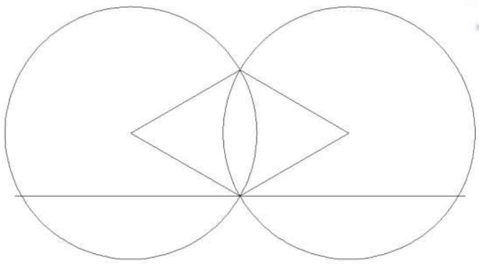
3. Mirror to opposite side

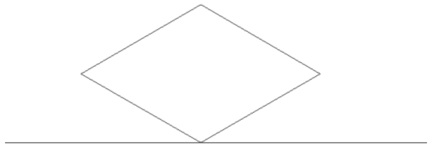


4. Command: c CIRCLE Specify center point for circle or [3P/2P/Ttr (tan tan radius)]:
   Specify radius of circle or [Diameter] <25>: 60



5. Then join the lines circles intersection point & delete the circle

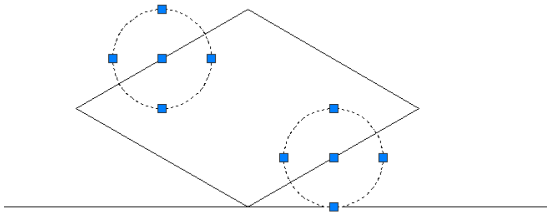




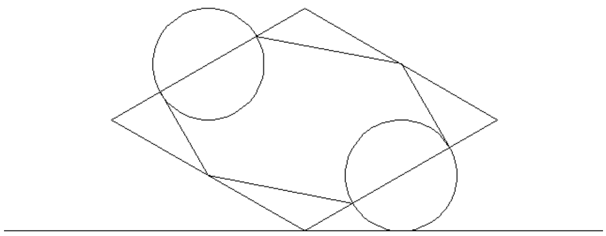
6. Draw a circle in the midpoint of line

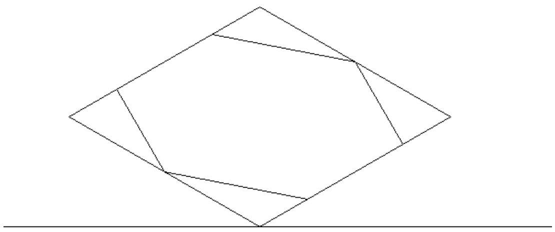
   Command: CIRCLE Specify center point for circle or [3P/2P/Ttr (tan tan radius)]:

   Specify radius of circle or [Diameter] <25>: d Specify diameter of circle <50>: 30

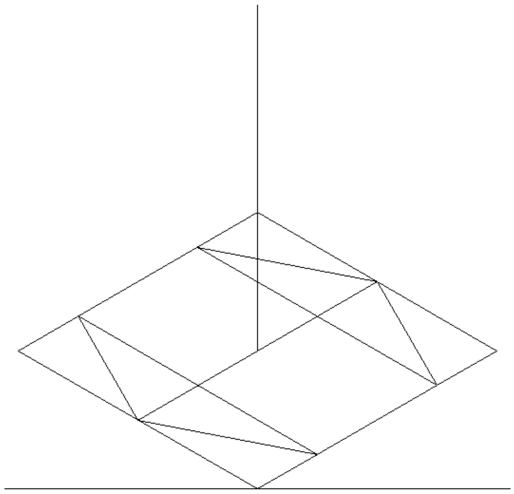


7. Join the line & delete the circle

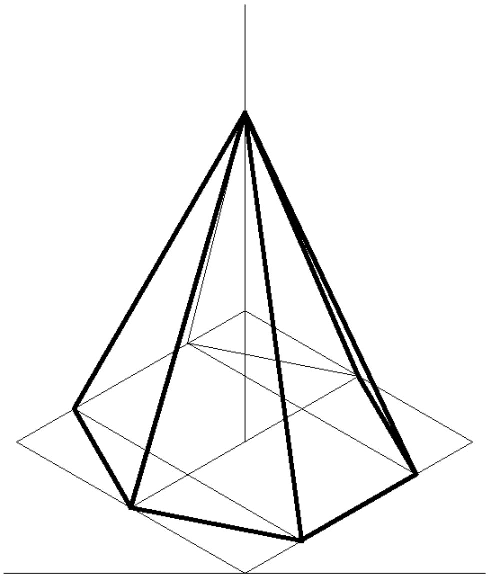




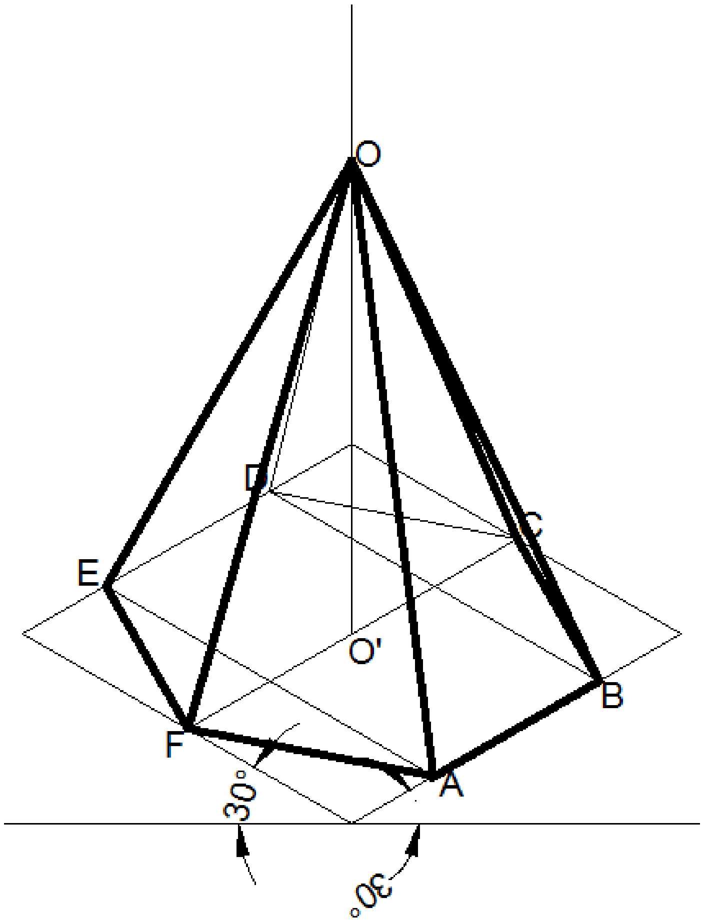
8. Line enter centre point distance 75



9. Then join the line endpoint to endpoint



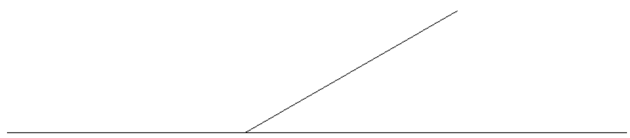
10. Then text & dimension commands are used to obtain the required plan and elevation as shown below.



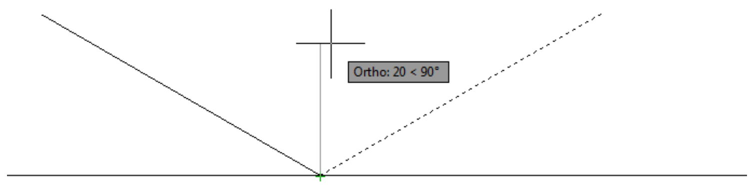
Problem 7: Draw the isometric view of a cylinder of base 50mm diameter and 70 mm height is resting with its base on H.P.

1. Command: l LINE Specify first point:

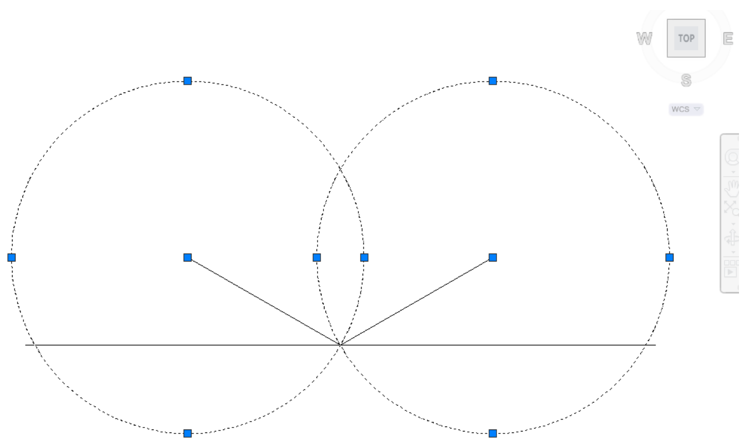
2. Command: l LINE Specify first point:
   Specify next point or [Undo]: @50<30



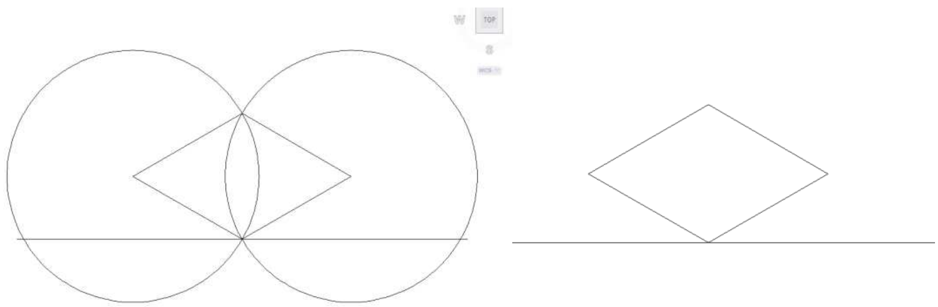
3. Mirror to opposite side



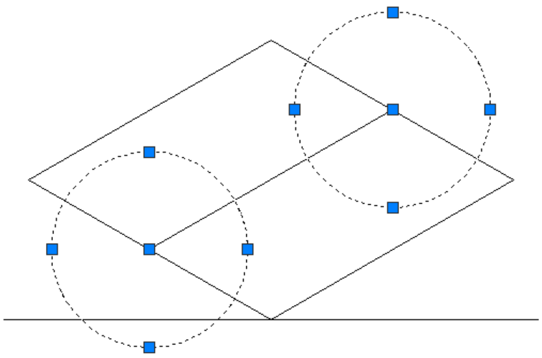
4. Command: c CIRCLE Specify center point for circle or [3P/2P/Ttr (tan tan radius)]:
   Specify radius of circle or [Diameter] <25>: 50



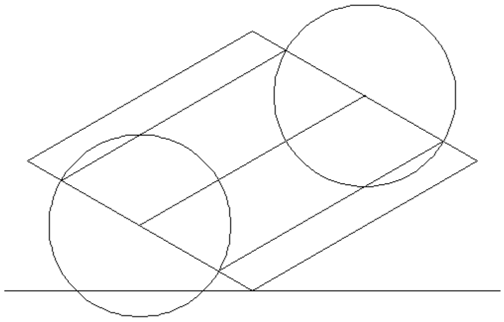
5. Then join the lines circles intersection point & delete the circle

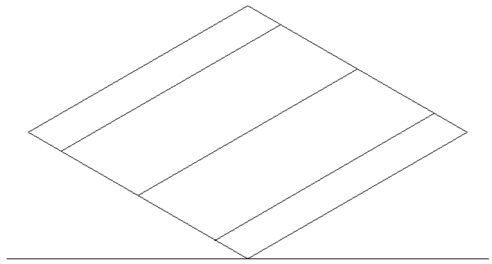


6. Draw a circle in the midpoint of line
   Command: CIRCLE Specify center point for circle or [3P/2P/Ttr (tan tan radius)]:
   Specify radius of circle or [Diameter] <25>: d Specify diameter of circle <50>: 35

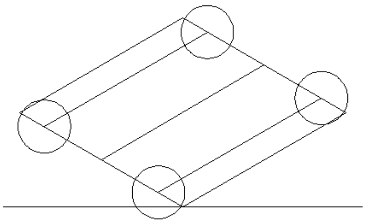


7. Join the line intersection point to intersection point & delete the circle

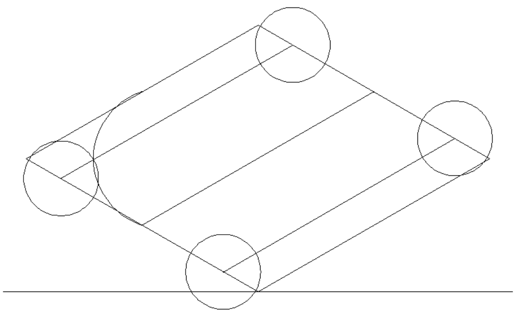


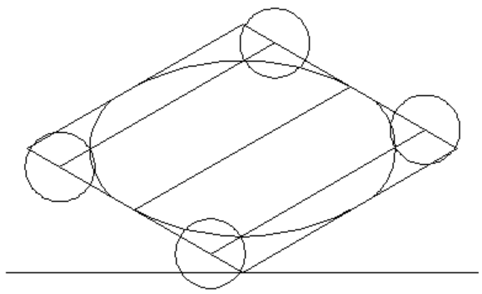


8. Command: c CIRCLE Specify center point for circle or [3P/2P/Ttr (tan tan radius)]:
   Specify radius of circle or [Diameter] <18>: 7

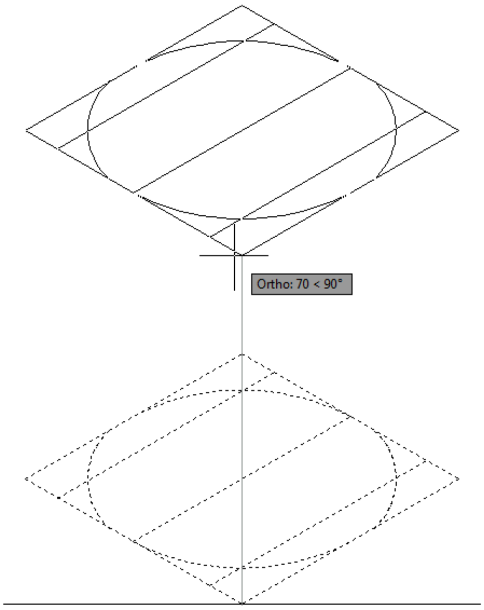


9. Then create arc in 3points

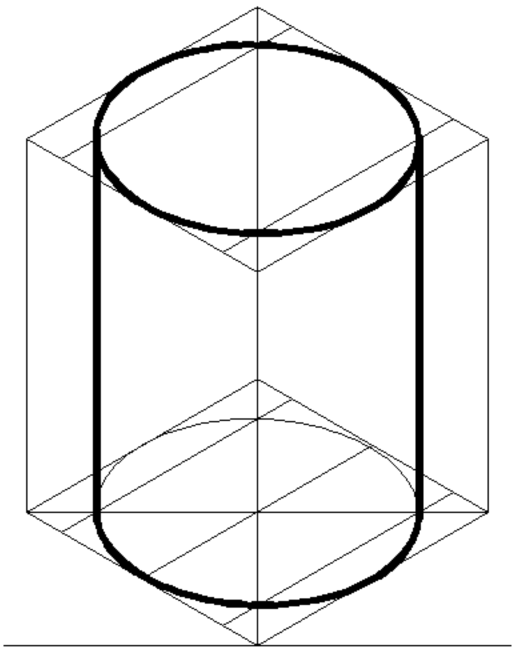




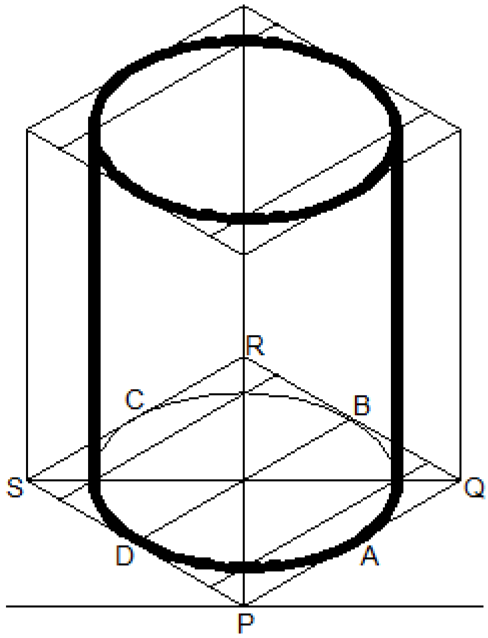
10. Then copy the object in perpendicular distance



11. Join line from end point to end point



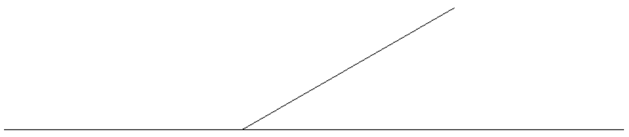
12. Add text on the drawing



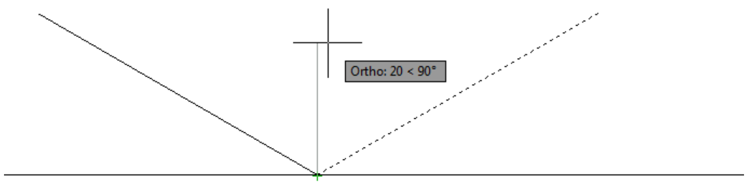
Problem 8: Draw the isometric view of a cone of base 40mm diameter and height 58mm when it rests with its base on H.P.

1. Command: l LINE Specify first point:

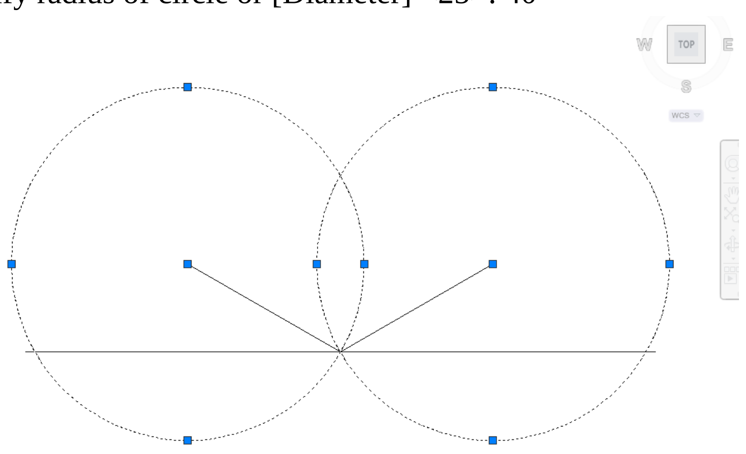
2. Command: l LINE Specify first point:
   Specify next point or [Undo]: @40<30



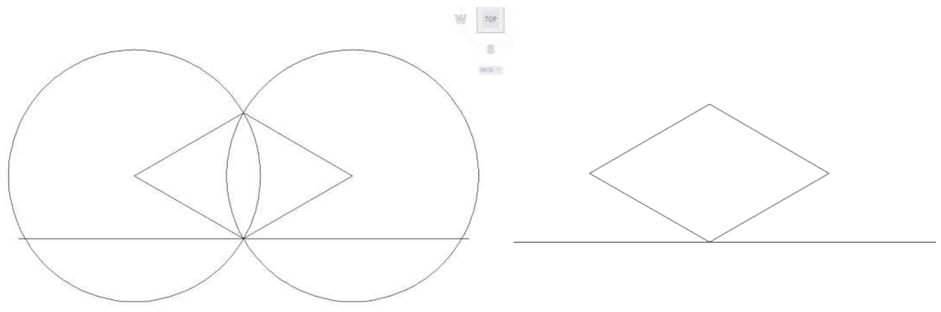
3. Mirror to opposite side



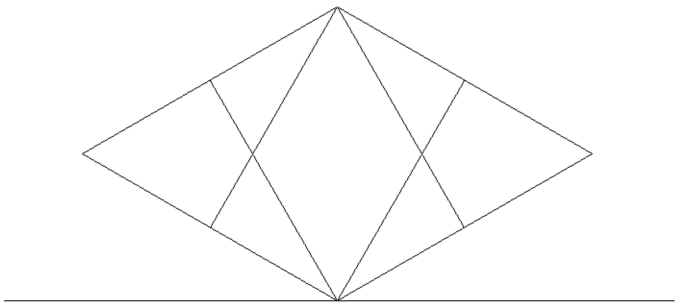
4. Command: c CIRCLE Specify center point for circle or [3P/2P/Ttr (tan tan radius)]:
   Specify radius of circle or [Diameter] <25>: 40



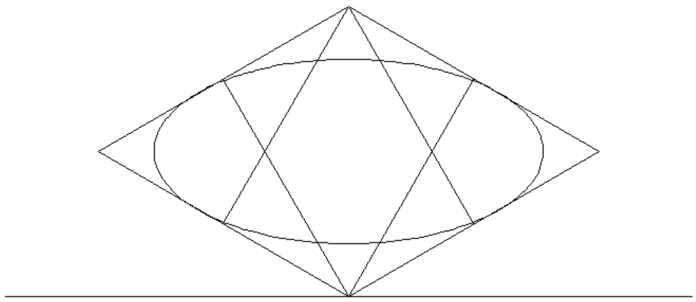
5. Then join the lines circles intersection point & delete the circle



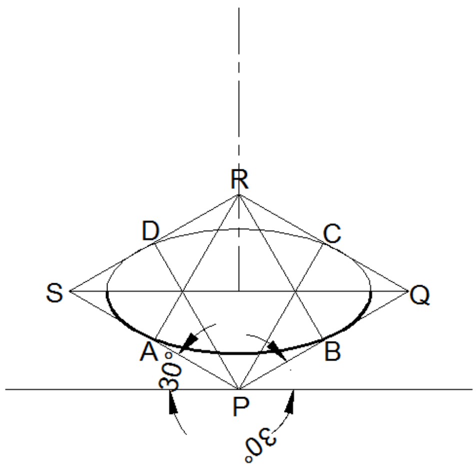
6. Join the line from midpoint to corner point



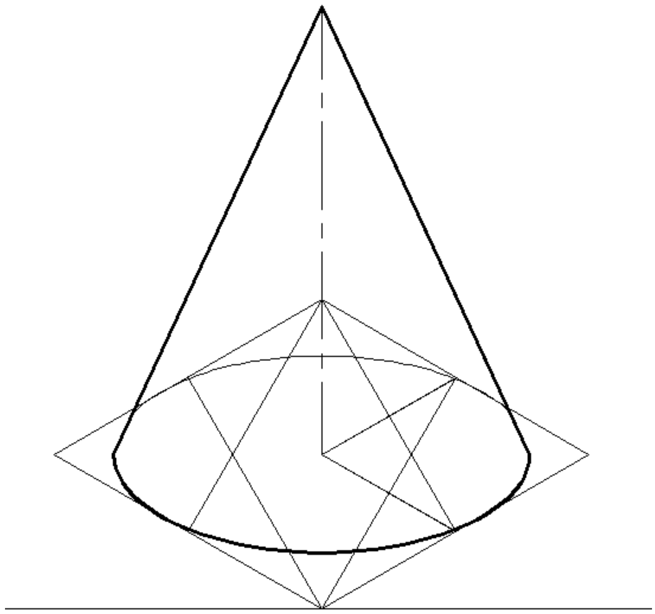
7. Then create elipse



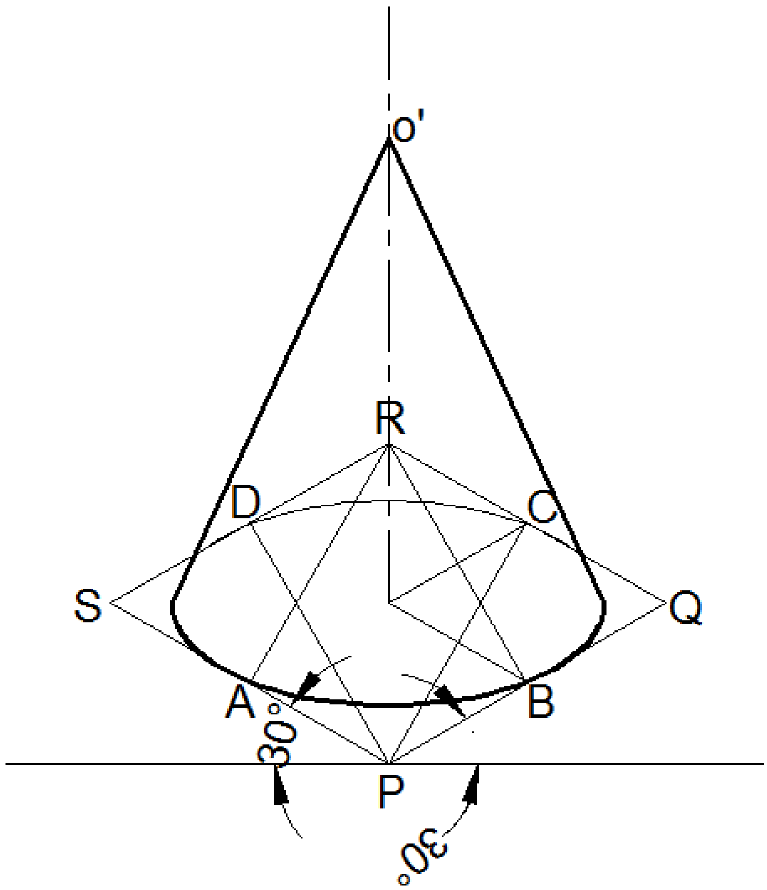
8. Command: l LINE Specify first point:
   Specify next point or [Undo]: 58



9. Line join from end point to end point



10. Add text on the drawing


o'
R
D
C
S
Q
A
B
P
30°
30°

EXERCISES

1. A line CD 80mm long is inclined at an angle of 30º to H.P. and 45 º to V./P. The point C is 20mm above H.P. and 30mm in front of V.P. Draw the projection of the straight line CD.

2. Draw the projection of a circle of 5cm diameter having its plane vertical and inclined at 30º to V.P. Its centre is 3cm above the H.P. and 2cm in front of the V.P.

3. Draw the projection of a pentagonal pyramid base 45mm edge and axis 65mm long, having its base on the H.P. and an edge of the base parallel to the V.P.

4. Draw the projection of a regular pentagonal prism side of base 30mm and axis 60mm long resting with its base on H.P. such that one of its rectangular faces is parallel to and 10mm in front of V.P.

5. Draw the isometric view of a pentagonal pyramid base 35mm edge and axis 65mm long, having its base on the H.P. and an edge of the base parallel to the V.P.

6. Draw the isometric projection of a regular pentagonal prism side of base 30mm and axis 60mm long resting with its base on H.P. such that one of its rectangular faces is parallel to V.P.