

E-Learning Material
on
Engineering Drawing
of
1st/2nd semester of all Engineering Branches



**State Council for Technical Education and Vocational
Training, Odisha
Bhubaneswar-751012**

E-Learning Material

Engineering Drawing

of

1st/2nd semester of all Engineering Branches of Diploma courses of SCTE&VT,
Odisha

Contents Written by

Mr. Satyananda Sethi, Lecturer (Civil), JES, Jharsuguda
Mr. Dhanurjaya Behera, Lecturer (Civil), JES, Jharsuguda
Mr. Swapnashish Patel, Lecturer (Civil), JES, Jharsuguda
Mr. Manas Ranjan Pradhan, Lecturer (Civil), UGMIT, Raygada

Reviewed and validated by

Mr. Pradipta Kumar Sahoo, Lecturer (Civil), BOSE, Cuttack
Mr. Shibasis Panda, Lecturer (Civil), GP, Balasore

All rights are reserved by SCTE&VT, Odisha. This material is meant to be used by students of Diploma Course of SCTE&VT, Odisha, as downloadable from SCTE&VT website free of cost. This material is not to be treated as Text Book, but be treated as reference material.

Published by

SCTE&VT, Odisha, Bhubaneswar-12

<https://sctevtodisha.nic.in/en/>

secretarysctevt@gmail.com, material.sctevt@gmail.com

CONTENTS

SL NO	NAME OF THE TOPIC	PAGE NO.
1	INTRODUCTION & DEMONSTRATION	1 – 13
2	TYPES OF LINES, LETTERING & DIMENSIONING	14 – 26
3	SCALES	27 – 35
4	CURVES	36 – 47
5	ORTHOGRAPHIC PROJECTIONS	48 – 74
6	SECTION AND DEVELOPMENTS	75 – 85
7	ISOMETRIC PROJECTIONS	86 – 98
8	BUILDING DRAWING	99 – 109
9	PRACTICES ON AUTOCAD	110 – 161

SYLLABUS

on

Engineering Drawing

(1st / 2nd Sem. Common)

(All drawings are to be made in First Angle Projection)

1. INTRODUCTION & DEMONSTRATION

- 1.1 Identify various sizes of drawing boards, drawing sheets as per BIS.
- 1.2 List the types of pencils, instruments, and scales (RF).
- 1.3 Demonstrate laying of drawing sheet, margin, standard layout and title block as per BIS, folding principle of drawings (blue prints, print outs etc).

2. TYPES OF LINES, LETTERING & DIMENSIONING

- 2.1 Demonstrate and explain the use of various types of lines.
- 2.2 Demonstrate the principle of single stroke, gothic lettering & numerals as per BIS.

3. SCALES

- 3.1 Significance of scales in drawing; different scales.
- 3.2 Define and draw plain scale and diagonal scale.

4. CURVES

- 4.1 Explain Conic sections with illustration, Explain terms like focus, vertex, directrix and eccentricity.
- 4.2 Draw conic sections by eccentricity method – Ellipse, Parabola and Hyperbola.
- 4.3 Draw Ellipse by concentric circle method and arc of circle method.
- 4.4 Draw parabola by Rectangle Method and Tangent Method.

5. ORTHOGRAPHIC PROJECTIONS

- 5.1 Demonstrate the principles of 1st angle and 3rd angle projections with the help of models and draw symbols.
- 5.2 Draw projection of points.
- 5.3 Draw projection of straight line (parallel to both planes, parallel to one and perpendicular to other, parallel to one and inclined to other and inclined to both reference planes).
- 5.4 Draw plane figure such as squares, rectangles, triangles, circle, Pentagon and hexagon (perpendicular to one plane and inclined to other).
- 5.5 Draw projections of solids such as prism, cylinder, cone, tetrahedron and pyramid in simple position (with axis parallel to one reference plane and perpendicular to other reference plane).

6. SECTION & DEVELOPMENTS

- 6.1 Draw the sectional projection & development of prism, cylinder, cone and pyramid in simple position by a cutting plane perpendicular to one reference plane and inclined to other reference plane.
- 6.2 Draw true shape of the cutting sections.

7. ISOMETRIC PROJECTIONS

Draw isometric view & Isometric projection of prism, pyramid, cone & cylinder with axis horizontal and vertical with construction of isometric scales.

8. BUILDING DRAWING

8.1 Explain terms related to building drawing.

8.2 Draw plan, elevation of single room building with verandah (Flat roof according to given line plan and specification).

9. PRACTICES ON AUTO CAD

9.1 Introduction-Settings, Limits etc.

9.2 Auto CAD commands – Draw commands (Line, circle, arc, polygon, ellipse, rectangle). Edit command, Dimension commands and Modify Commands for two dimensional drafting only.

9.3 Exercise for practice using Auto CAD.

9.3.1 Orthographic projections of lines, planes and solids as per chapter 5.0.

9.3.2 Isometric projection as per Chapter 7.0.

Note : Focus should be on Hands on Practice of student using AutoCAD software

Books Recommended

1. Machine Drawing by Basudeb Bhattacharya, Oxford University Press.
2. A Text Book of Engineering Drawing by Dr. R.K. Dhawan.
3. A Text Book of Engineering Graphics & Auto CAD by K Venugopal.
4. A Text book of Engineering Drawing by N.D. Bhatt.
5. Engineering Drawing by P.S. Gill.
6. A Introduction to Auto CAD – 2012 by George Omura, Wiley India Publishers.

CHAPTER – 1

1.1 INTRODUCTION & DEMONSTRATION

Engineering drawing is a two dimensional representation of three dimensional objects. In general, it provides necessary information about the shape, size, surface quality, material, manufacturing process, etc. of the object. It is the graphic language from which a trained person can visualize objects.

1.2 LIST OF INSTRUMENTS USED IN DRAWING:-

The Instruments and other aids used in drafting work are listed below:

1. Pencil
2. Drawing board
3. Setsquare
4. Mini drafter
5. Instrument box
6. Protractor
7. Measurement Scale
8. Drawing sheet
9. Drawing clips or Drawing pins

1. Pencils :

Pencils with leads of different degrees of hardness or grades are available in the market. The hardness or softness of the lead is indicated by 3H, 2H, H, HB, B, 2B, 3B, etc. The grade HB denotes medium hardness of lead used for general purpose. The hardness increases as the value of the numeral before the letter H increases. The lead becomes softer, as the value of the numeral before B increases.

- HB Soft grade for Border lines, lettering and free sketching
- H Medium grade for Visible outlines, visible edges and boundary lines
- 2H Hard grade for construction lines, Dimension lines, Leader lines, Extension lines, Centre lines, Hatching lines and Hidden lines.

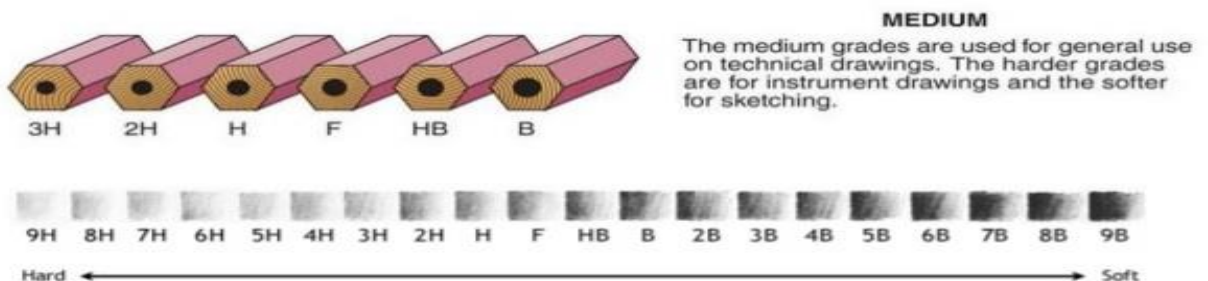


Fig 1.1 Pencil

2. Drawing Board :

Drawing board (Fig 1.1) is one of the main equipment of Draughtsman. It is used for supporting the drawing paper/tracing paper for making drawings. It is made of well seasoned wood strips of about 25 mm thick, free from knots and warping. It should be softer enough to allow insertion and removal of drawing pins. Two battens are fastened to the board by screws, in slotted joints. They prevent warping and at the same time permit expansion and contraction of the strips due to the change of moisture in the atmosphere.

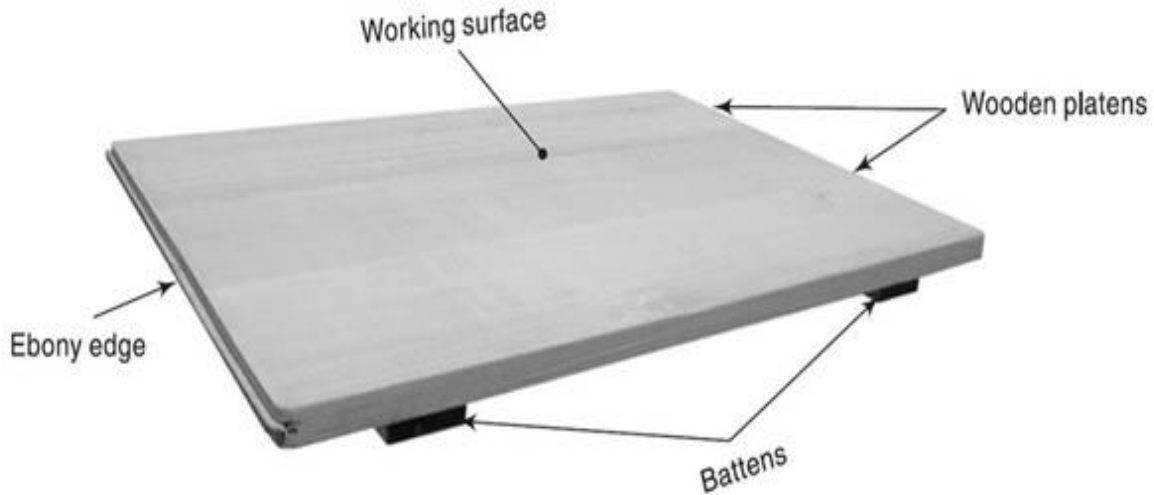


Fig 1.2 Drawing Board

One of the shorter edges of the drawing board is provided with an “ebony edge” (hard wood) fitted perfectly straight.

Standard drawing boards are designated as follows in Table 1.1 as per IS: 1444-1989.

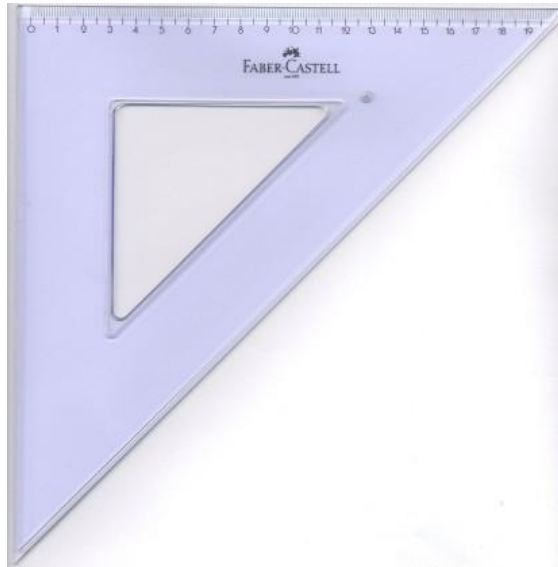
	Designation	Size (mm)
1	D0	1500 x 1000 x 25
2	D1	1000 x 700 x 25
3	D2	700 x 500 x 15
4	D3	500 x 350 x 15

Table 1.1 Different sizes of Drawing Boards

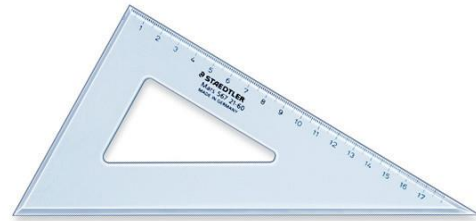
The working edge (ebony) must be straight. Now-a-days the drawing boards are available with laminated surfaces. The flatness can be checked by placing a straight edge on its surface. If no light passes between them, the surface is perfectly flat.

3. Set Square :

They are used to construct the most common angles (i.e. 30° , 45° and 60°) in technical drawings. The $45^\circ \times 45^\circ$ and $30^\circ \times 60^\circ$ triangles are the most commonly used for ordinary work. They are shown in the fig. 1.3 below.



$45^\circ \times 45^\circ$ Set Square



$30^\circ \times 60^\circ$ Set Square

Fig 1.3 Set Squares

4. Mini-Drafter :

Mini-drafter consists of an angle formed by two arms with scales marked and rigidly hinged to each other. It combines the functions of T-square, set-squares, scales and protractor. It is used for drawing horizontal, vertical and inclined lines, parallel and perpendicular lines and for measuring lines and angles.



Fig 1.4 Mini Drafter



Fig 1.5 Drawing Board and Mini Drafter Assembly

5. Instrument Box:

Instrument box contains

- i. Compasses,
- ii. Dividers and
- iii. Inking pens.

The important point is the position of the pencil lead with respect to the tip of the compass. It should be at least 1 mm above as shown in the Fig 1.7. Because the tip goes into the board for grip by 1mm.



Fig 1.6 Instrument Box

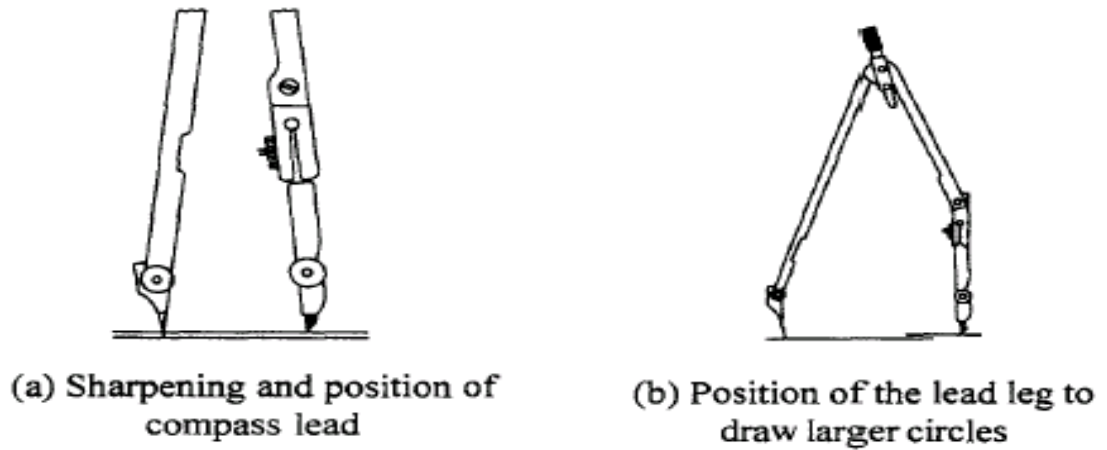
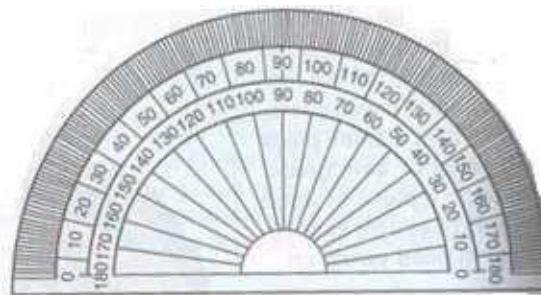


Fig 1.7 Compass

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° to 180° . Least count of the protractor is generally 1° . Like set square protractor is also made of transparent celluloid or plastic material.



Semi-circular protractor

Fig 1.8 Protractor

7. Measurement Scale:

A number of kinds of scales are available for varied types of engineering design. Scales with beveled edges graduated in mm are usually used. Least count of such scale is generally 1 mm.

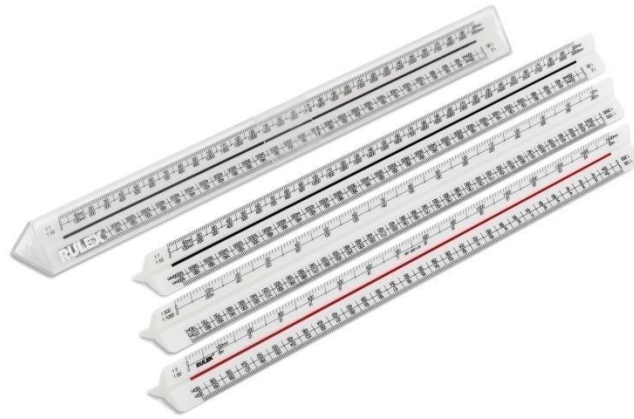


Fig 1.9 Measurement Scale

8. Drawing Sheet:

These are of two types:

- Hand-made paper
- Mill-made paper

Hand-made papers have rough surfaces, pale in colour and not used for regular work, but meant for charts. Mill-made papers are most commonly used for regular work, and are available in different sizes and rolls. They are specified by their weight in kg per ream or density in grams per square meter.

Size of drawing sheets (in mm):

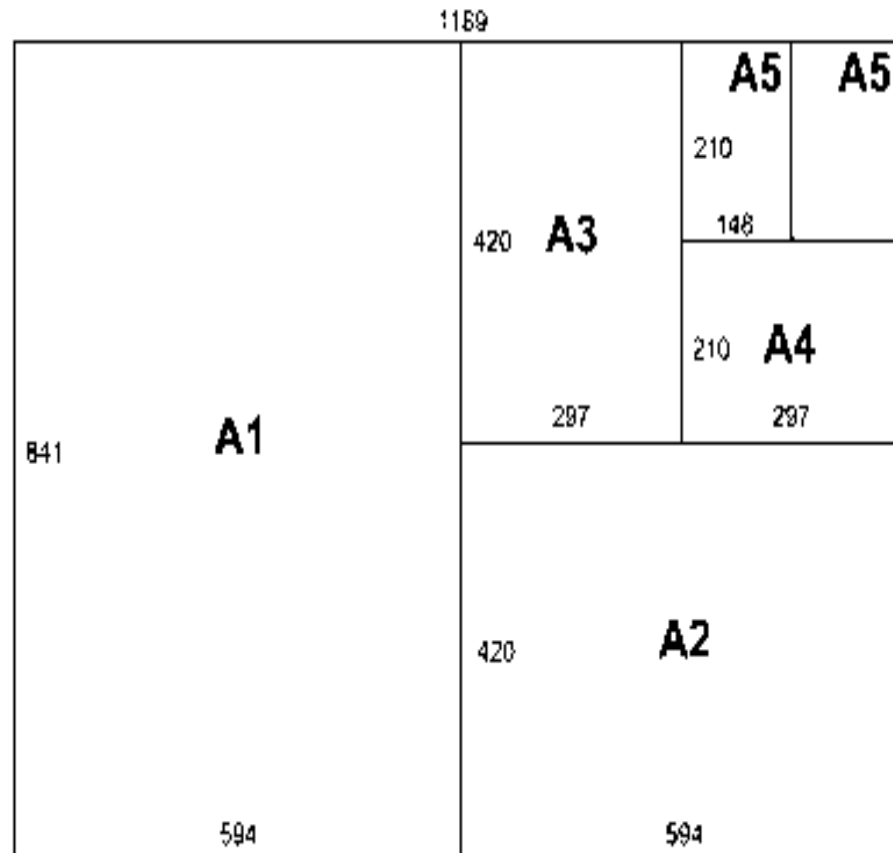
While working or handling, the papers are liable to tear on the edges. So slightly large size (untrimmed) sheets are preferred. They are trimmed afterwards. IS: 10811:1983 lays down such as designation of preferred trimmed and untrimmed sizes. The basic principle involved in arriving at the sizes of the drawing paper is as under. The area of the biggest size (A0) is 1m^2 and its length and breadth are in the ratio $1:2 = (\sqrt{2})$.

Designation of sheets :

The drawing sheets are designated by symbols such as A0, A1, A2, A3, A4 and A5. A0 being the largest. Table 1.2 below gives the length and breadth of the above sizes of sheets. For class work use of A2 size drawing sheet is preferred.

Designation	Dimension in mm (Trimmed Size)
A0	841 X 1189
A1	594 X 841
A2	420 X 594
A3	297 X 420
A4	210 X 297

Table. 1.2 Different size of Drawing Sheets



Total rectangle = A0

Fig 1.10 Standard size of drawing sheets according to I.S.I.(All dimensions are in mm)

9. Drawing Clips or Drawing Pins :

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

They are generally made up of steel or plastic.



Fig 1.11 Drawing Clips



Fig 1.12 Drawing Pins

1.3 SCALE (R.F) :

Dimensions of large objects must be reduced to accommodate on standard size drawing sheet. This reduction creates a scale of that reduction ratio, which is generally a fraction & such a scale is called Reducing Scale and the ratio is called Representative Factor.

$$RF = \frac{\text{Dimension of drawing}}{\text{Dimension of object}} = \frac{\text{Length of object in drawing}}{\text{Actual length}}$$

Note : For computing R.F, the numerator and denominator should be in same units.

1.4 STANDARD LAYOUT OF DRAWING SHEET:

The layout of a drawing sheet used on the shop floor is shown in Fig.1.13, The layout suggested to students is shown in Fig.1.14.

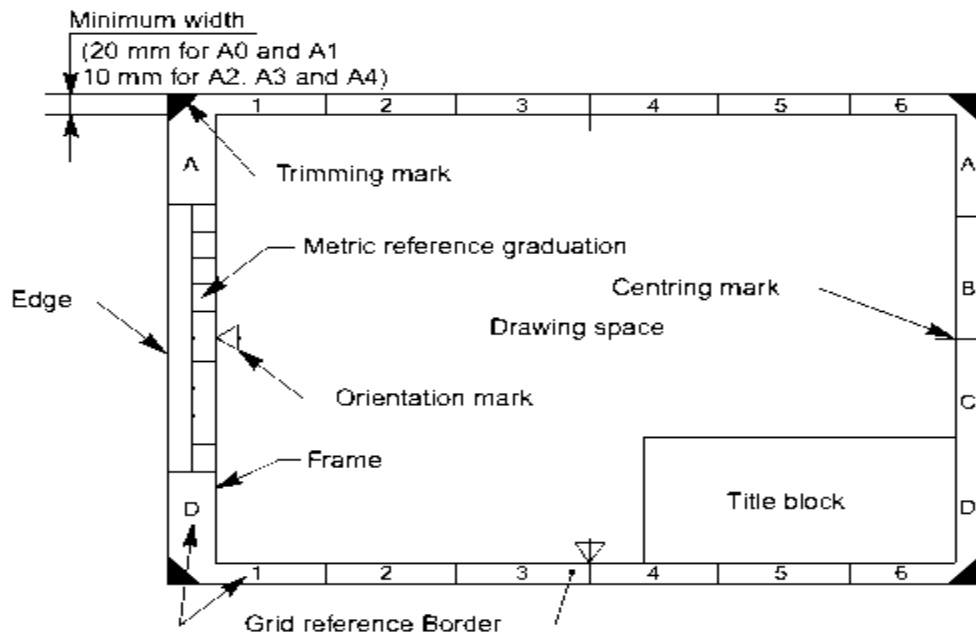


Fig 1.13 General features of a drawing sheet

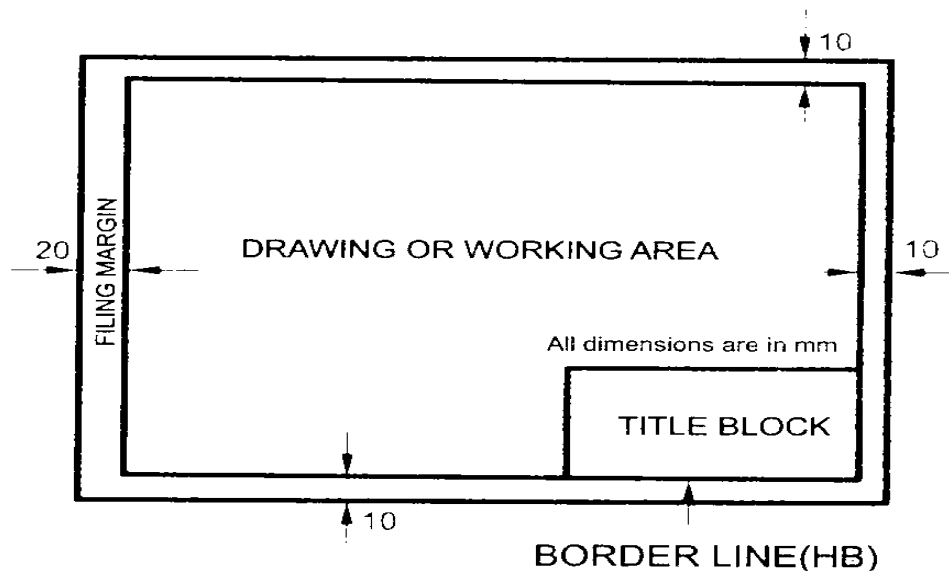


Figure.1.14 Layout of sheet for class work

All dimensions are in mm

1.5 FOLDING PRINCIPLE OF DRAWINGS

Method of folding of printed drawing sheets as per BIS SP: 46-2003:

When drawing sheets are in more numbers, they have to be folded and kept in order to save the trace required for preserving them (Fig1.15).

Requirement

While folding the drawings following care to be taken.

1. It is required to fold the drawing sheets such that, they should not get defaced or damaged.
2. Drawing sheet to be folded such that the title block is easily visible to retrieve it and keeping

it back.

The following is the method of folding printed drawing sheets for Drawing Sheet of size A1, A2 and A3 as recommended by BIS SP 46-2003.

SHEET DESIGNATION	FOLDING DIAGRAM	LENGTHWISE FOLDING	CROSSWISE FOLDING
A0 841 x 1189			
A1 594 x 841			
A2 420 x 594			
A3 297 x 420			

Fig 1.15 : Method of folding drawing sheet

1.6 TITLEBLOCK :

The title block should lie within the drawing space at the bottom right hand corner of the sheet. The title block can have a maximum length of 185 mm and width of 65 mm providing the following information.

- Title of the drawing.
- Drawing number.
- Scale.
- Symbol denoting the method of projection.
- Name of the firm, and
- Initials of staff, who have designed, checked and approved.

The title block suggested for students class work is shown in Fig.1.16.

15 10 10 10 10 10	NAME	NAME OF INSTITUTE		65
	ROLL NO.			
	REGD. NO.	SHEET NO.	PROJECTION	
	BRANCH	SCALE:		
	SEMESTER	CHECKED BY:		
	DATE	TITLE OF THE SHEET		
	85	100		

TITLE BLOCK FOR CLASS WORK

Fig 1.16: Title block for class work

All dimension are in mm

Another title block according to B.I.S. specification is given in Fig 1.17.

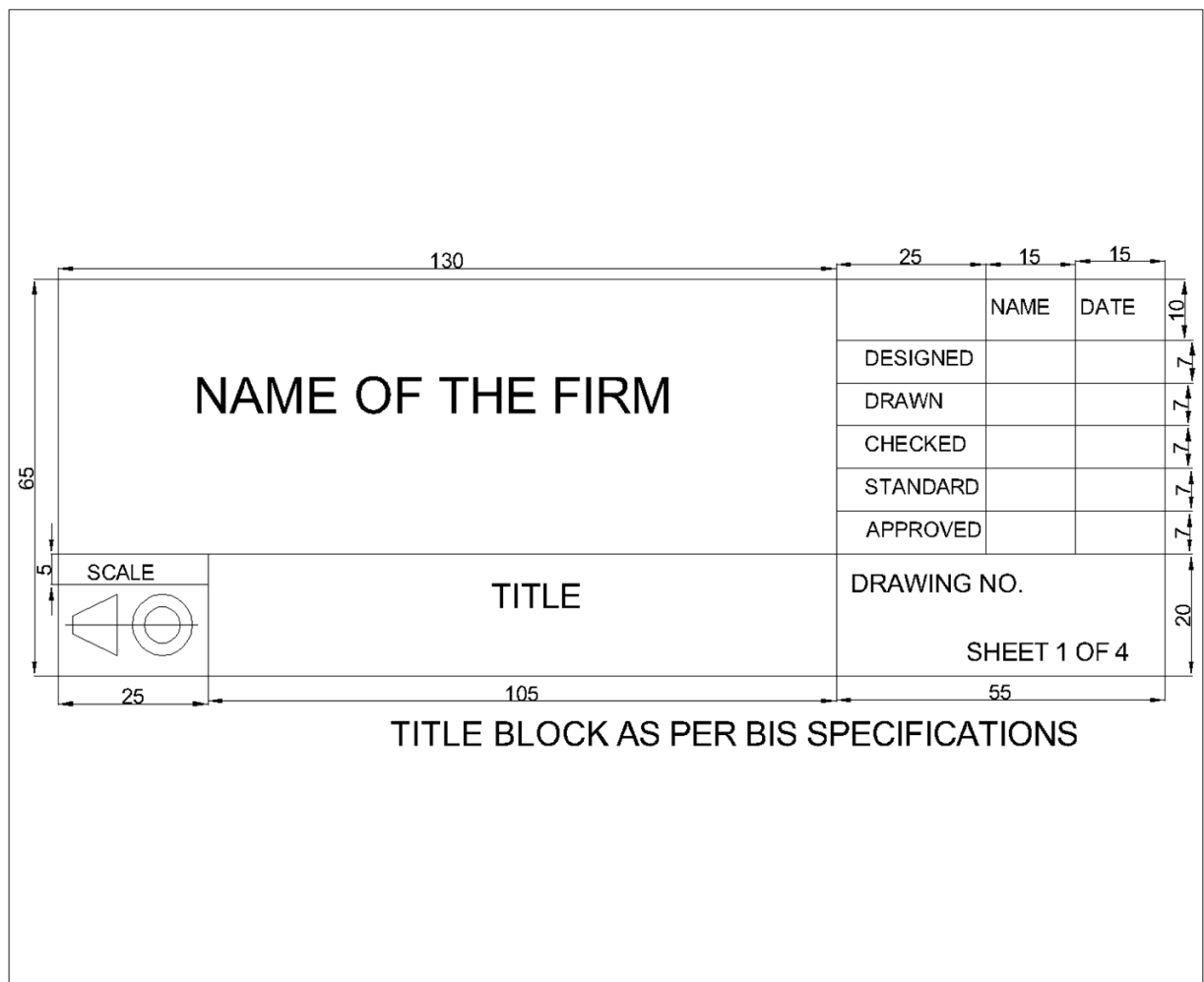


Fig 1.17 : Title block as per B.I.S specifications

All dimension are in mm

EXERCISES

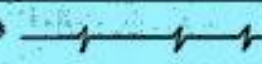
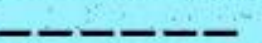
1. What is Engineering Drawing?
2. What are the standard sizes of drawing boards and drawing sheets as suggested by BIS?
3. Draw a title block for your drawing sheets prepared in class room?
4. Mention the use of mini drafter?
5. How to fold drawing sheets as per BIS?

CHAPTER – 2

TYPES OF LINES, LETTERING AND DIMENSIONING

2. TYPES OF LINES, LETTERING & DIMENSIONING

Line is one important aspect of technical drawing. Lines are always used to construct meaningful drawings. Various types of lines are used to construct drawing, each line used in some specific sense. Lines are drawn following standard conventions mentioned in BIS (SP46:2003). A line may be curved, straight, continuous, segmented. It may be drawn as thin or thick.

<i>Line</i>	<i>Description</i>	<i>General applications</i>
A 	Continuous thick	A1 Visible outlines A2 Visible edges
B 	Continuous thin (straight or curved)	B1 Imaginary lines of intersection B2 Dimension lines B3 Projection lines B4 Leader lines B5 Hatching B6 Outlines of revolved section in place B7 Short centre lines
C 	Continuous thin freehand**	C1 Limits of partial or interrupted views and sections, if the limit is not a chain thin line
D* 	Continuous thin (straight) with zigzags	D1  do 
E 	Dashed thick**	E1 Hidden outlines E2 Hidden edges
F 	Dashed thin	F1 Hidden outlines F2 Hidden edges

G _____	Chain thin	G1 Centre lines G2 Line of symmetry G3 Trajectories
H _____	Chain, thin, thick at ends and changes of direction	H1 Cutting planes
J _____	Chain thick	J1 Indication of lines or surfaces to which a special requirement applies

Fig 2.1

Line Strokes

Line strokes refer to the directions of drawing straight and curved lines. Vertical and inclined lines are drawn from top to bottom, horizontal lines are drawn from left to right. Curved lines are drawn from left to right or top to bottom.

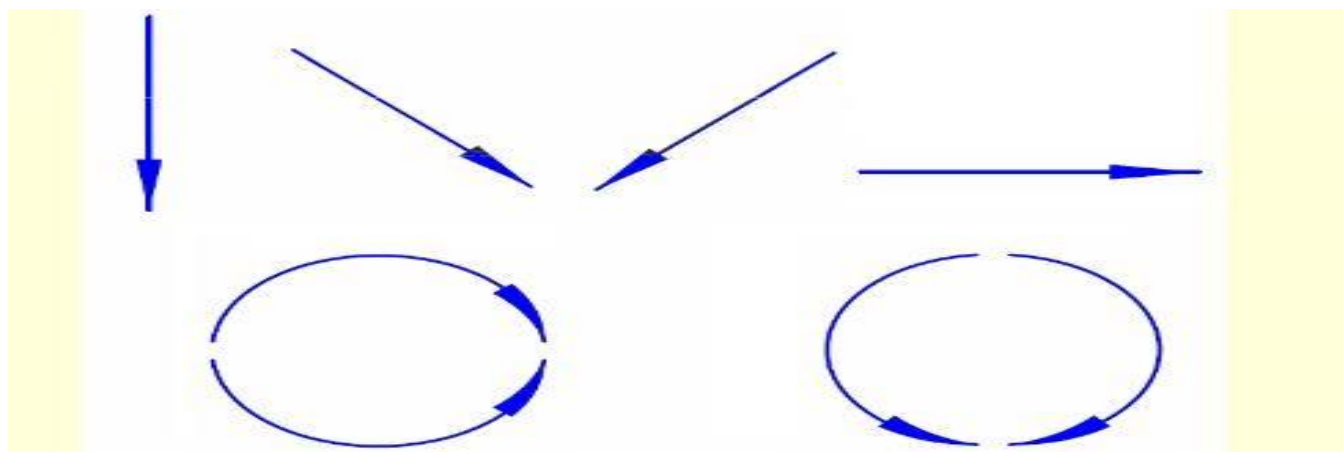
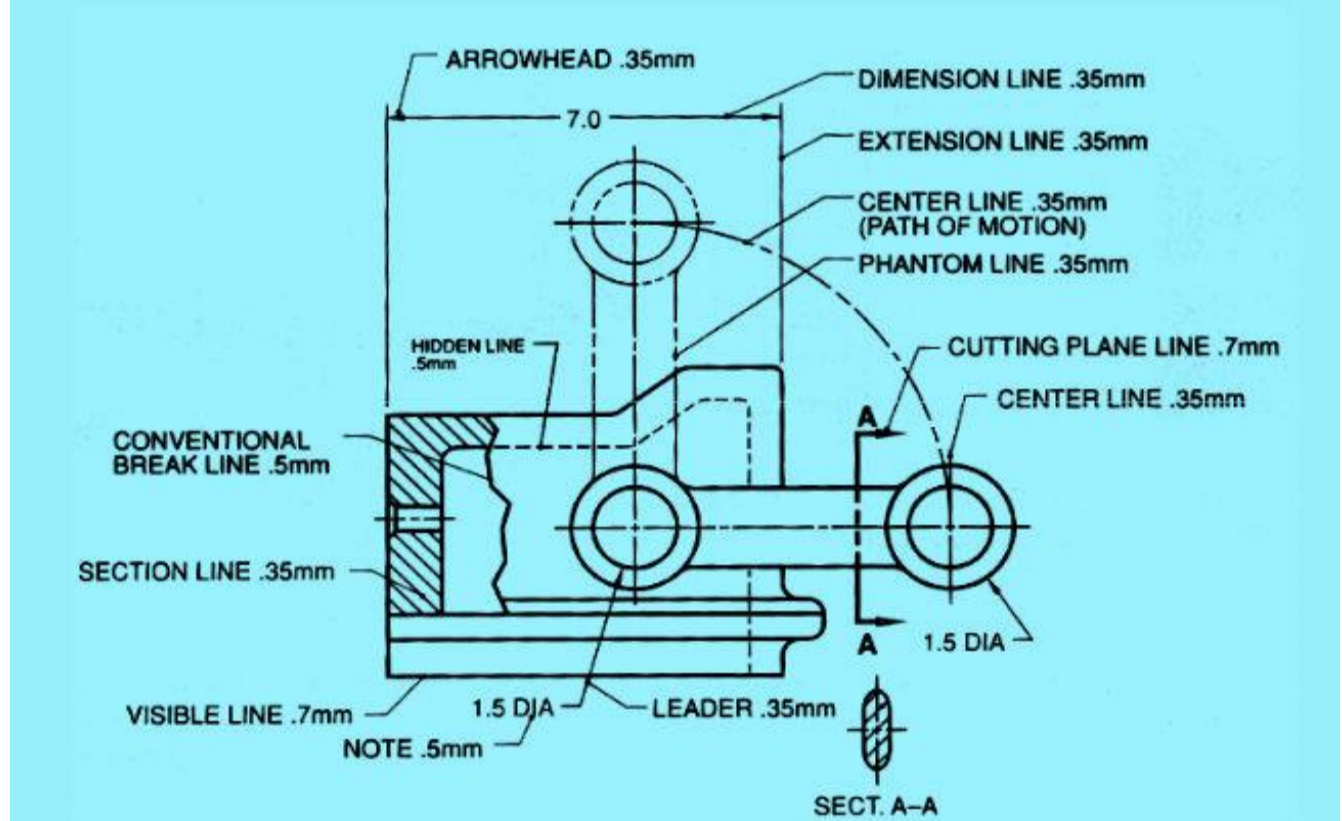


Fig 2.2

Uses of different types of lines in a given drawing



2.2 Demonstrate the principle of single stroke, gothic lettering & numerals as per BIS.

Single Stroke Letters

The word single-stroke should not be taken to mean that the lettering should be made in one stroke without lifting the pencil. It means that the thickness of the letter should be uniform as if it is obtained in one stroke of the pencil.

Single-stroke letters are of two types:

- Vertical
- Inclined. (Inclined letters lean to the right, the slope being 75° with the horizontal)

According to the height of letters, they are classified as:

- Lettering 'A'
- 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 drawing. **The ratio of height to width varies but in case of most of the letters it is 6 : 5.**

LETTERING A $\left(d = \frac{h}{10}\right)$

Characteristic		Ratio	Dimensions (mm)						
Lettering height									
Height of capitals	h	$\left(\frac{14}{14}\right) h$	2.5	3.5	5	7	10	14	20
Height of lower-case letters	c	$\left(\frac{10}{14}\right) h$	–	2.5	3.5	5	7	10	14
Spacing 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 lines	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

LETTERING B $\left(d = \frac{h}{10}\right)$

Characteristic		Ratio	Dimensions (mm)						
Lettering height									
Height of capitals	h	$\left(\frac{10}{10}\right) h$	2.5	3.5	5	7	10	14	20
Height of lower-case letters	c	$\left(\frac{7}{10}\right) h$	–	2.5	3.5	5	7	10	14
Spacing between characters	a	$\left(\frac{2}{10}\right) h$	0.5	0.7	1	1.4	2	2.8	4
Minimum spacing of base lines	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

Fig 2.4

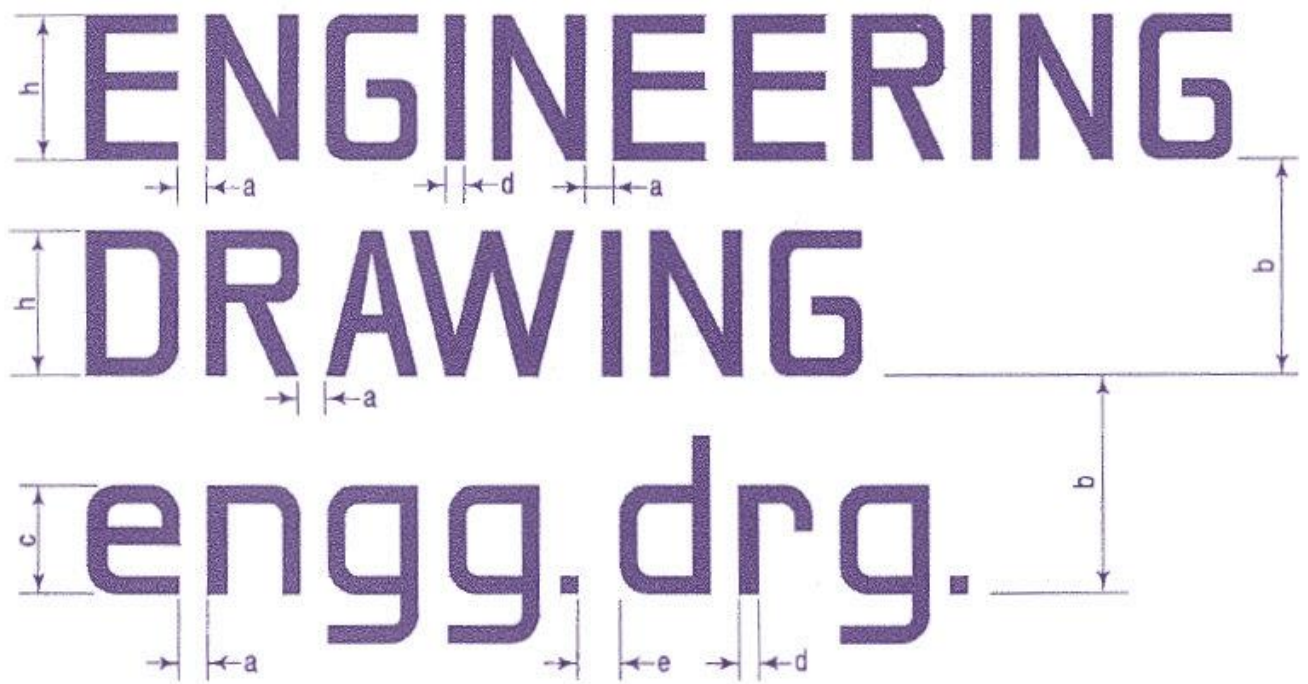


Fig 2.5 Single-stroke vertical capital letters and figures :



Fig 2.6 Single-stroke inclined capital letters and figures:



Fig 2.7 Single-stroke vertical & inclined lower case letters and figures :

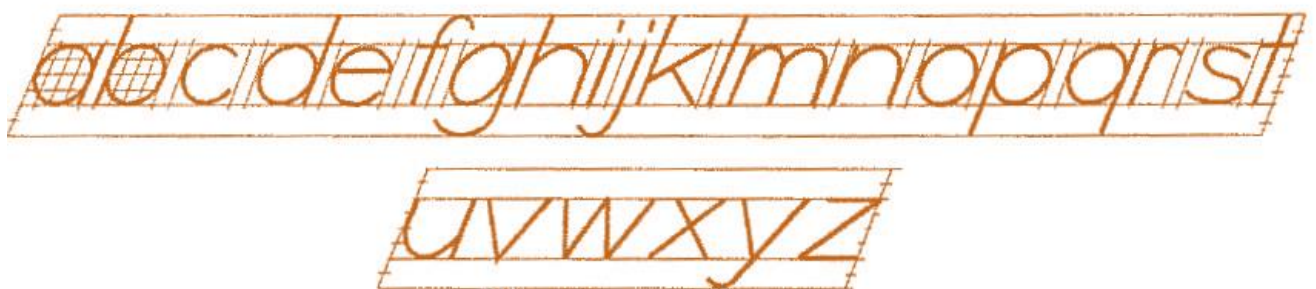
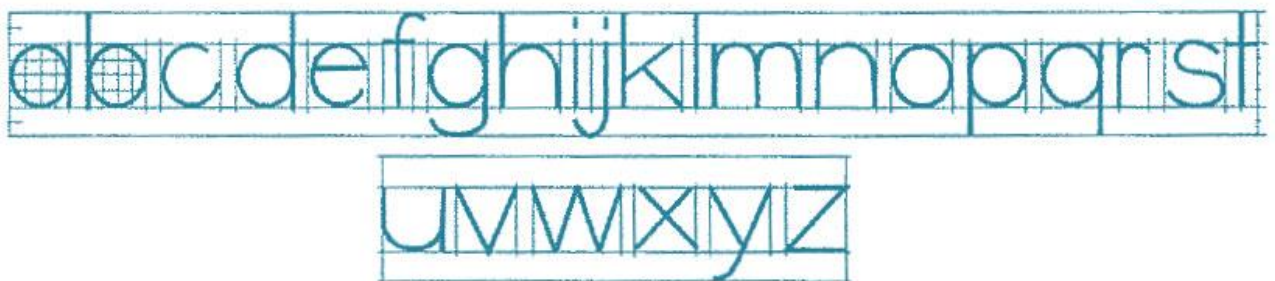
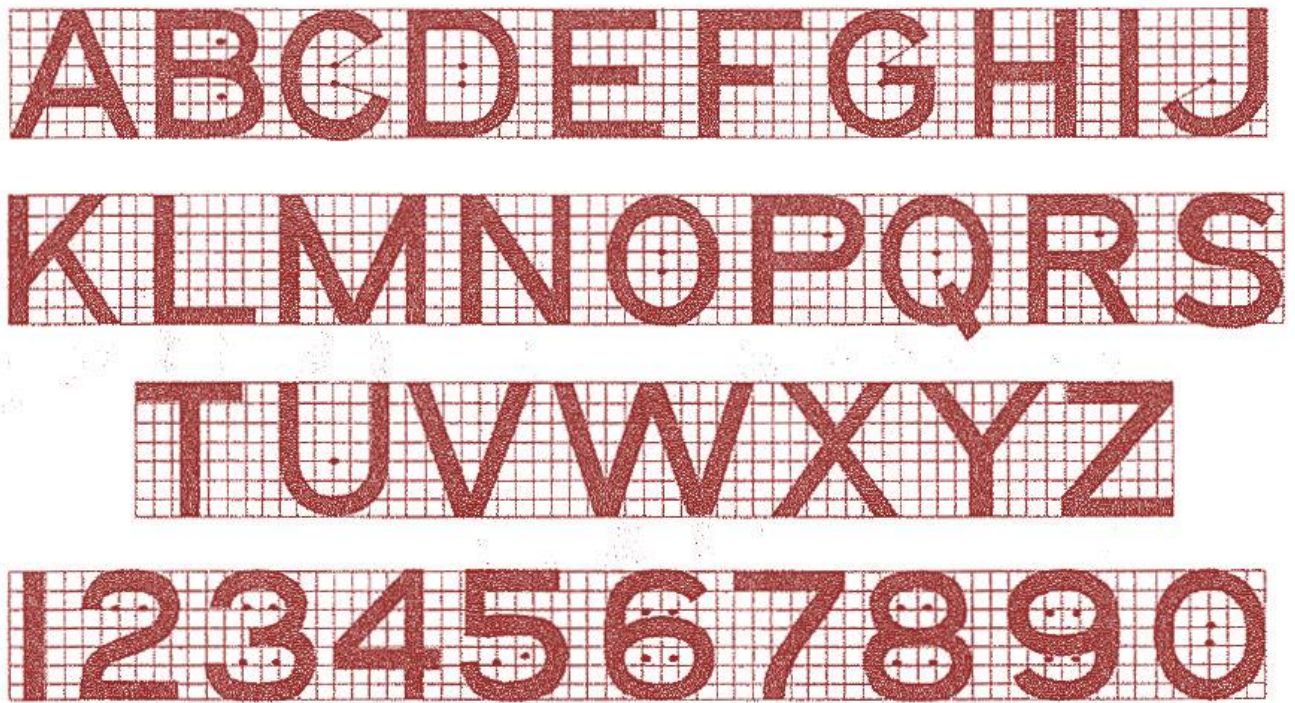


Fig 2.8

Gothic letters:

Stems of single-stroke letters, if given more thickness, form what are known as *gothic* letters. The thickness of the stem may vary from 1/5 to 1/10 of the height of the letters.



Here stem thickness is taken as $\frac{1}{7}$ times height.

Dimensioning

Dimensioning is the process of specifying part's information by use of lines, numbers, symbols and notes.

The general principle of dimensioning :

- As far as possible, it should be placed outside the view.
- It should be taken from a visible line rather than hidden lines.
- Dimensioning of a centre line should be avoided except when the centre line passes through the centre of a-holes.
- The dimension should be placed on the view or section which is most clear to the corresponding features.
- Each dimension should be dimensioned once on a drawing.
- Each drawing should have the same dimensional unit.
- More than one dimension should not be used for features of the same parts.

Elements of Dimensioning

Dimension Line: Dimension line is a continuous thin line. It is indicated by arrowheads, it is drawn parallel to the surface whose length must be indicated.

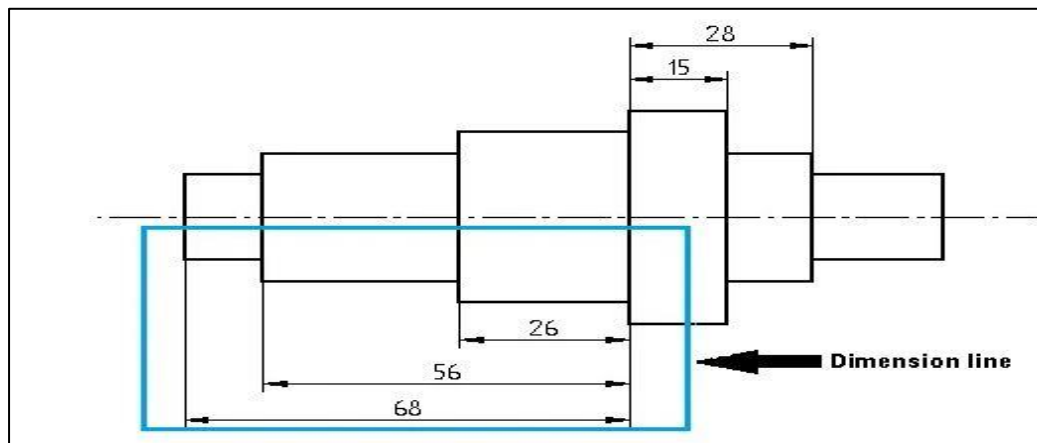


Fig 2.10

Projection or Extension Line : A projection line or extension line, it is a thin line. It is drawn perpendicular to the surface which is to be dimensioned. The projection line slightly extends than the dimension line.

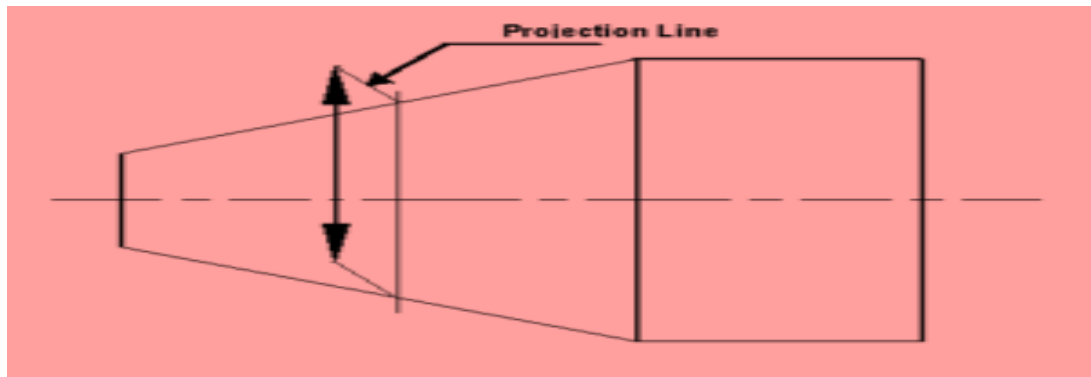


Fig 2.11

Constructions line: A construction line is a thin line drawn to indicate the dimension line. The construction line is extended slightly beyond the point intersection.

Arrowheads: Arrowheads are used to indicate the dimension line. Usually, the arrowhead must include angles of a minimum of 15° . The Arrowhead may be open or close or closed and filled.

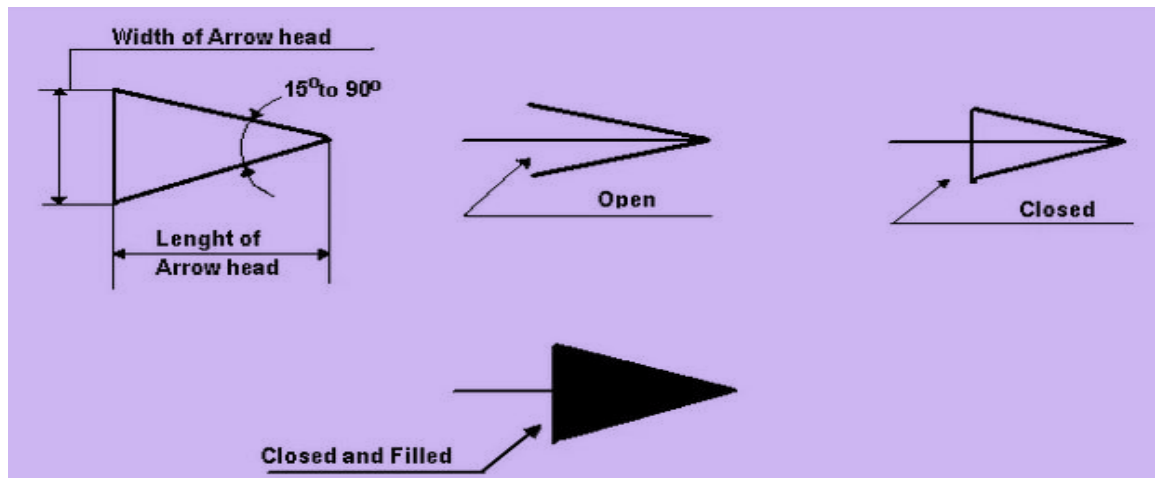


Fig 2.12

Leader or Pointer Lines: These are thin continuous lines drawn from a dimension figure to the feature to which it refers. Leader line is drawn may be 30° or 60° to the bottom of dimensions.

Dimension Figure: These are drawn may be vertical or inclined to indicate the height of the dimension figure.

Units of Dimensions

The dimension unit is millimetre. The unit of the dimension is omitted while writing the dimension fig. and a footnote stating “**ALL DIMENSIONS ARE IN MM**” is written at the prominent place on the drawing sheet.

Dimensioning common features

Dimensioning diameters :

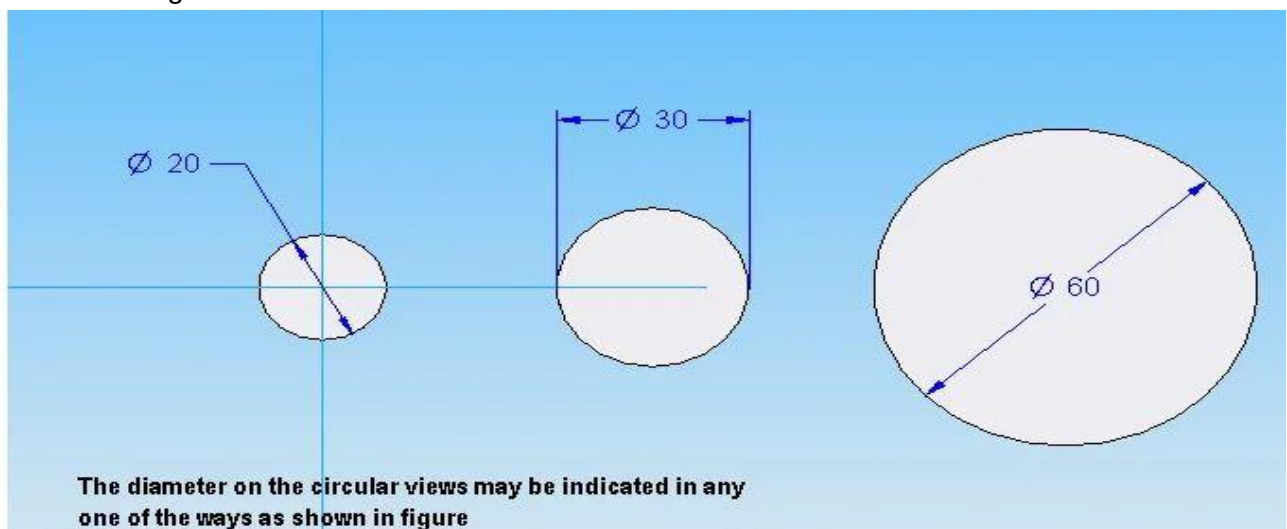


Fig 2.13

Dimensioning Radius :

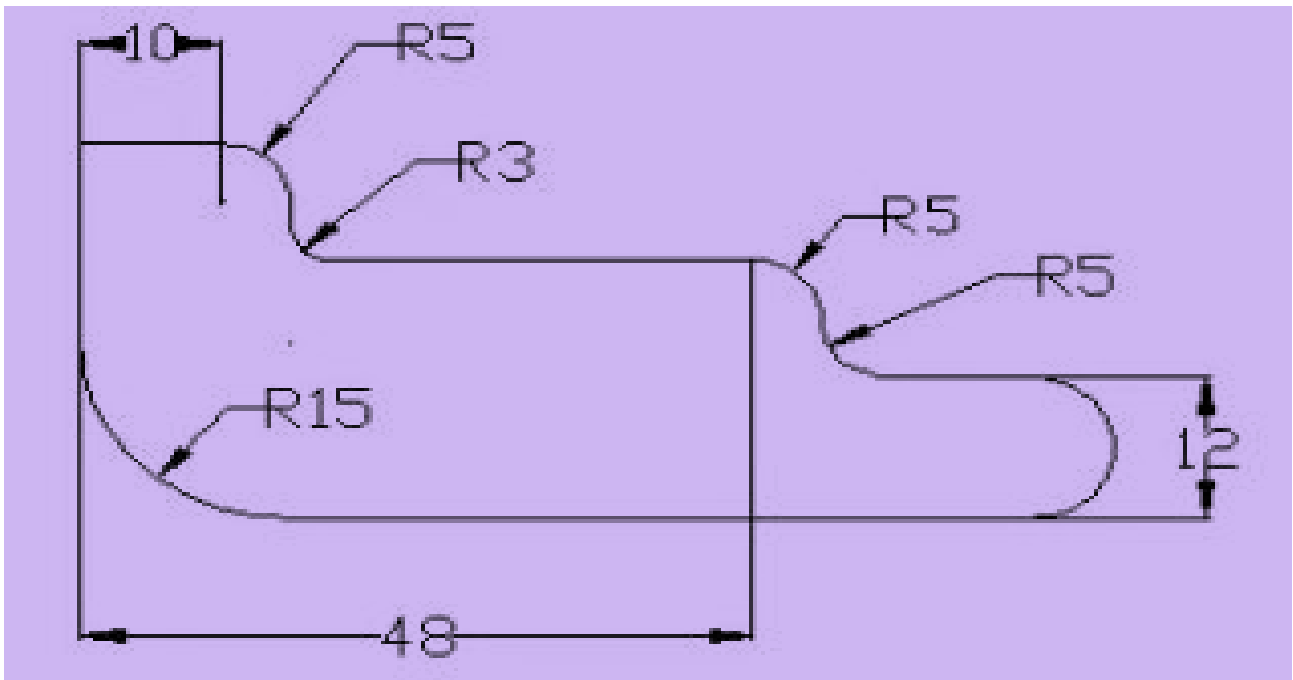


Fig 2.14

Dimensioning Arcs :

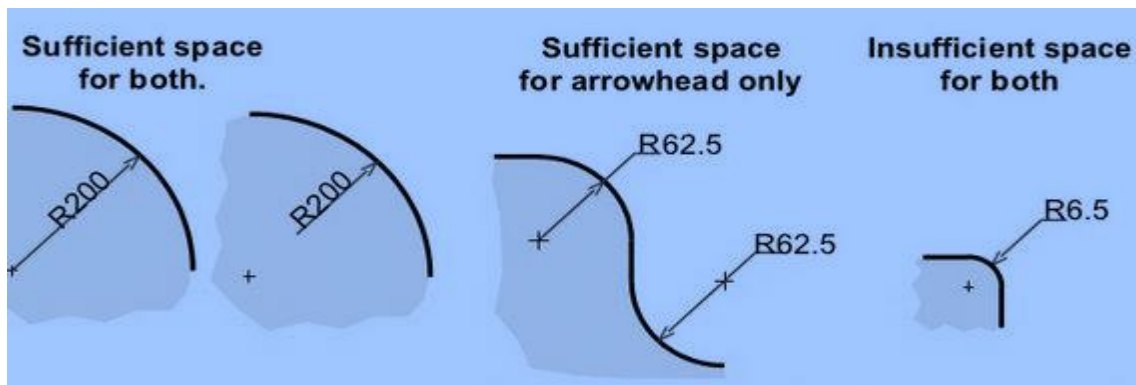


Fig 2.15

Dimensioning Chords :

It is a linear distance between any two points of an arc.

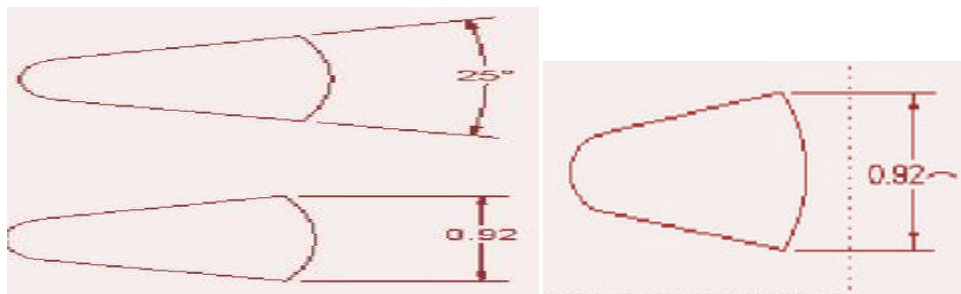


Fig 2.16

Dimensioning Angles :



Fig 2.17

Types of Dimensioning systems:

Aligned System :

In this type of dimensioning systems, Dimensions are placed above the dimension lines which are drawn without any break and written parallel to them.

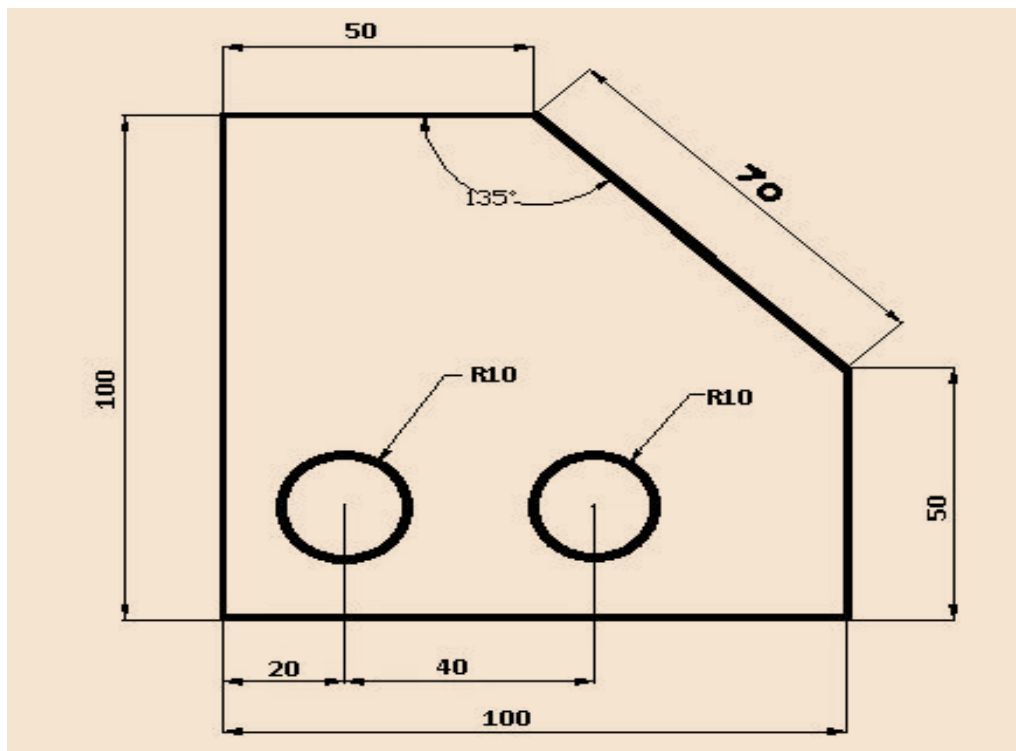


Fig 2.18

Unidirectional System:

Dimensions are inserts by breaking the dimension lines at the middle.

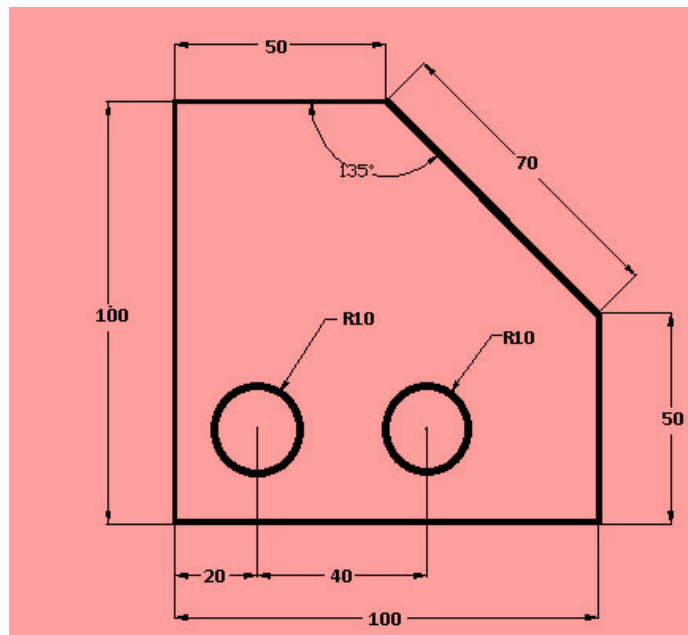


Fig 2.19

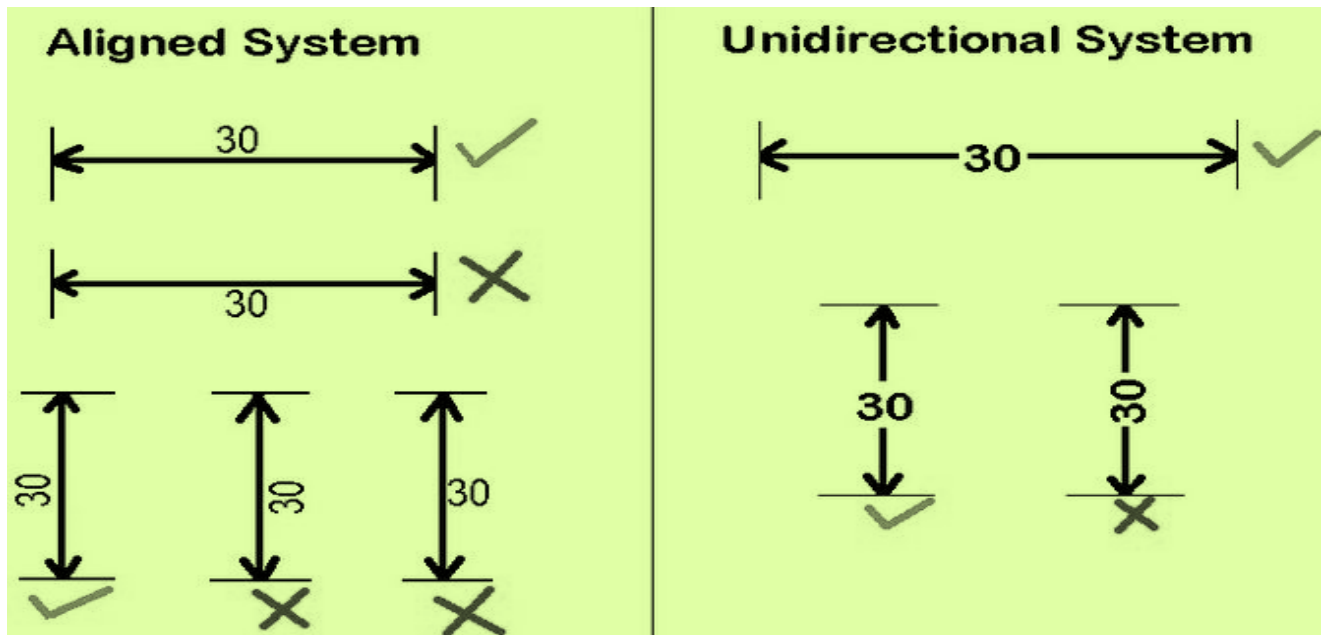


Fig 2.20

EXERCISES

1. What is the purpose of sectioning of an object?
2. How hidden lines are represented?
3. Show different method of indicating diameters?
4. What do you mean by lettering?
5. What do you mean by single stroke letters?
6. What is the slope of inclined letters?
7. Write down CIVIL in single stroke vertical letter.
8. Write down ENGINEERING in single stroke inclined letter.
9. Draw the different types of lines and name them.

CHAPTER-3

SCALE

3.1 Introduction

A scale is defined as the ratio of the linear dimensions of the object as represented in a drawing to the actual dimensions of the same.

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

3.2 Purpose of Scale

Scales are used for the following purposes :

1. To prepare a drawing on a reduced scale so that large object can be accommodated on the limited size of drawing sheet.
e.g. building, machine parts etc.
2. To prepare the drawing of a very small objects.
e.g. parts of wrist watches, measuring instruments etc. on enlarged scale in order to give better understanding and to study the details of the minor parts of the objects.
3. To measure linear measurements of the object under measurement directly without involving any calculations.
4. To measure and set off dimensions as per scales decided upon or given before starting the drawing.

3.3 Types of scale :

3.3.1 Reducing Scale :

It is the scale in which the actual measurements of objects are reduced and represented on the drawing sheet.

Generally the drawings are very big objects like buildings, machine parts; town plans etc are prepared in reduced scale. The standard proportions are :

1:2, 1:5, 1:10, 1:20, 1:50, 1:100, 1:200, 1:500, 1:1000, 1:2000, 1:5000, 1:10000
for this scale, $RF < 1$

Example-If the actual size of the object is 100cm then using R.F. of 1:10, the size of the object would be $100 \times (1/10) = 10\text{cm}$ in drawing.

3.3.2 Full Size Scale :

In this scale the actual measurements of the objects are represented on the drawing. In this scale the usual proportion is 1:1. For this scale $R.F. = 1$

Example- If the actual size of the object is 150cm then using R.F. of 1:1, the size of the object would be $150 \times (1/1) = 150$ cm in drawing.

3.3.3 Enlarging Scale :

It is the scale in which the actual measurements of the objects are increased in some proportion to accommodate object details on the drawing sheet.

Generally the drawings of very small objects like watches, electronic devices, precision instruments etc. are prepared in enlarging scale. The standard enlarging scales are : 50:1, 20:1, 10:1, 5:1, 2:1 for this scale, R.F.>1

Example- If the actual size of the object is 2cm then using R.F. of 50:1, the size of the object would be $2 \times (50/1) = 100$ cm in drawing.

3.4 Representative Fraction (R.F.)

The ratio of the dimension of the object shown on the drawing to its actual size is called the Representative Fraction (R.F.).

Mathematically S.F or R.F = $\frac{\text{Distance of the object on drawing}}{\text{Actual distance of the object}}$

Both in
same units

NOTE :

The dimensions in both numerator and denominator of the fraction must be in the same units. Since it is a ratio it has no units.

example : If 1cm length of drawing represents 5m length of the object then
 $RF = 1\text{cm}/5\text{m} = 1\text{cm}/500\text{cm} = 1/500$

3.5 UNITS OF MEASUREMENTS

Metric measures :

i. Linear Measures

1 KILOMETRE = 10 HECTOMETRES
1 HECTOMETRE = 10 DECAMETRES
1 DECAMETRE = 10 METRES
1 METRE = 10 DECIMETRES
1 DECIMETRE = 10 CENTIMETRES
1 CENTIMETRE = 10 MILIMETRES

Classification of Scales

The scales used in engineering drawing are classified as follows:

i. Plain scale or simple scale

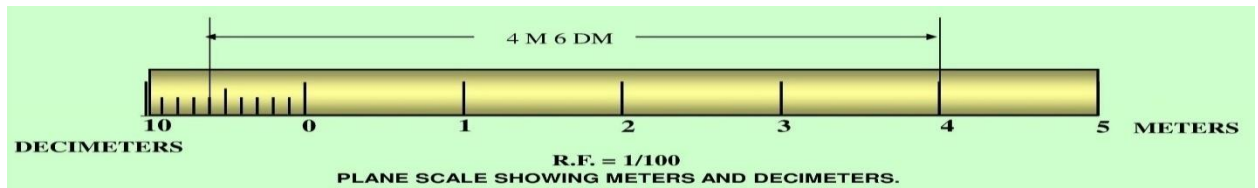


Fig 3.1

ii. Diagonal scale

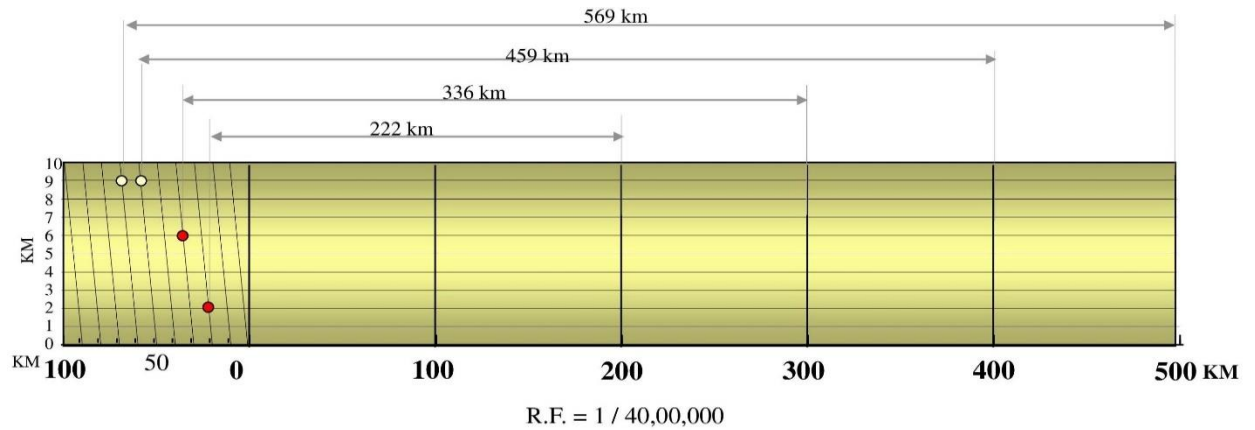


Fig 3.2

iii. Comparative or Corresponding Scale

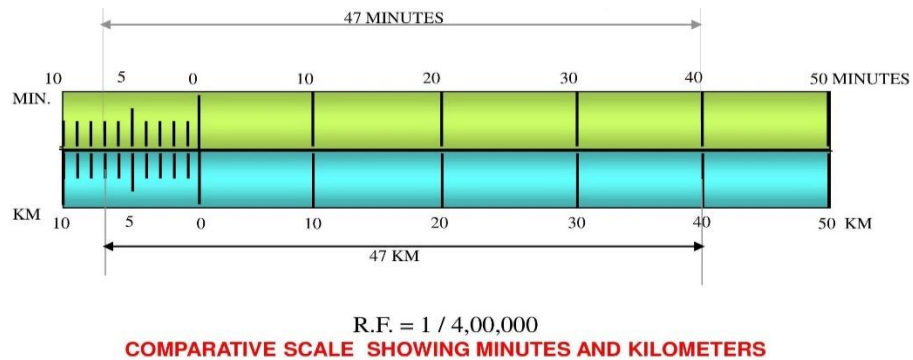


Fig 3.3

iv. Vernier Scale

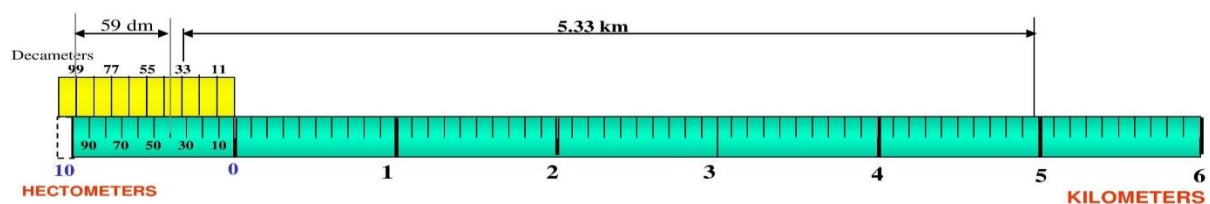


Fig 3.4

v. **Scale of chords**

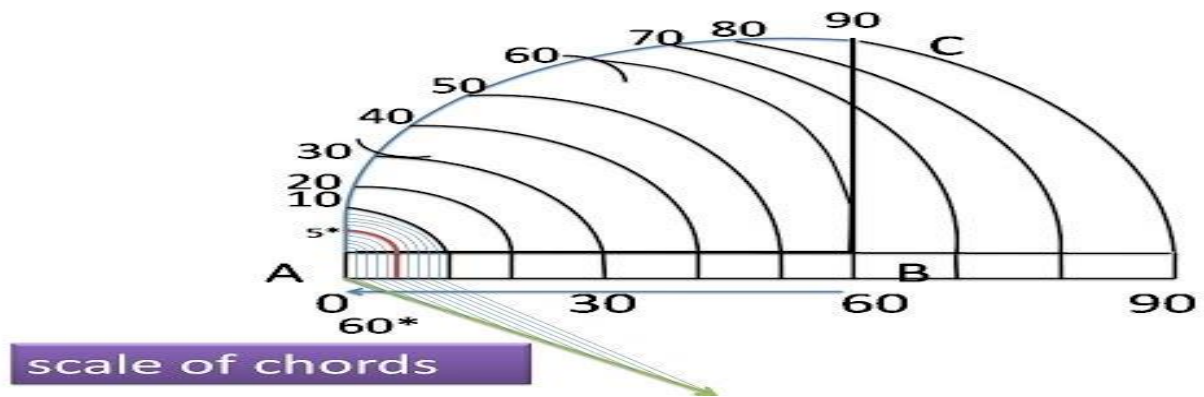


Fig 3.5

Here in this chapter we will discuss about the plain scale and diagonal scale only.

3.5 Plain Scale

This type of scale represents two units or a unit and its sub-division.

Q. No. 1.

Draw a scale 1 cm = 1m to read decimeters, to measure maximum distance of 6 m. Show on it a distance of 4 m and 6 dm

CONSTRUCTION :

- Calculate R.F.= (DIMENSION OF DRAWING /DIMENSION OF OBJECT)
 $R.F.= 1\text{cm}/ 1\text{m} = 1/100$
Length of scale = R.F. X max. distance = $(1/100) \times 600 \text{ cm} = 6 \text{ cm}$
- Draw a line 6 cm long and divide it in 6 equal parts. Each part will represent larger division unit.
- Sub-divide the first part which will represent second unit or fraction of first unit.
- Place (0) at the end of first unit. Number the units on right side of Zero and subdivisions on left-hand side of Zero. Take height of scale 5 to 10 mm for getting a look of scale.
- After construction of scale mention its RF and name of scale as shown.
- Show the distance 4 m 6 dm on it as shown Fig. 3.6.

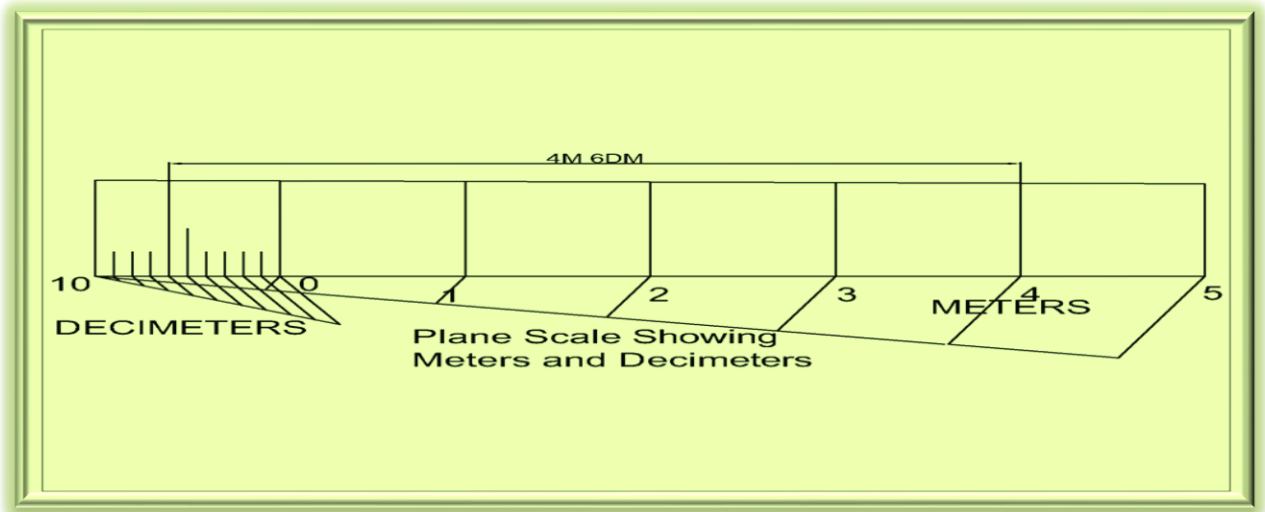


Fig 3.6

Q. No. 2.

In a map a 36 km distance is shown by a line 45 cms long. Calculate the R.F. and construct a plain scale to read kilometers and hectometers, for max. 12 km. Show a distance of 8.3 km on it.

CONSTRUCTION :

- a. Calculate R.F.

$$R.F. = 45 \text{ cm} / 36 \text{ km} = 45 / (36 \times 1000 \times 100) = 1 / 80,000.$$

$$\text{Length of scale} = R.F \times \text{max. distance} = 1 / 80000 \times 12 \text{ km} = 15 \text{ cm}$$

- b. Draw a line 15 cm long and divide it in 12 equal parts. Each part will represent larger division unit.
 c. Sub-divide the first part which will represent second unit or fraction of first unit.
 d. Place (0) at the end of first unit. Number the units on right side of Zero and subdivisions on left-hand side of Zero. Take height of scale 5 to 10 mm for getting a look of scale.
 e. After construction of scale mention it's RF and name of scale as shown.
 f. Show the distance 8.3 km on it as shown in Fig 3.7.

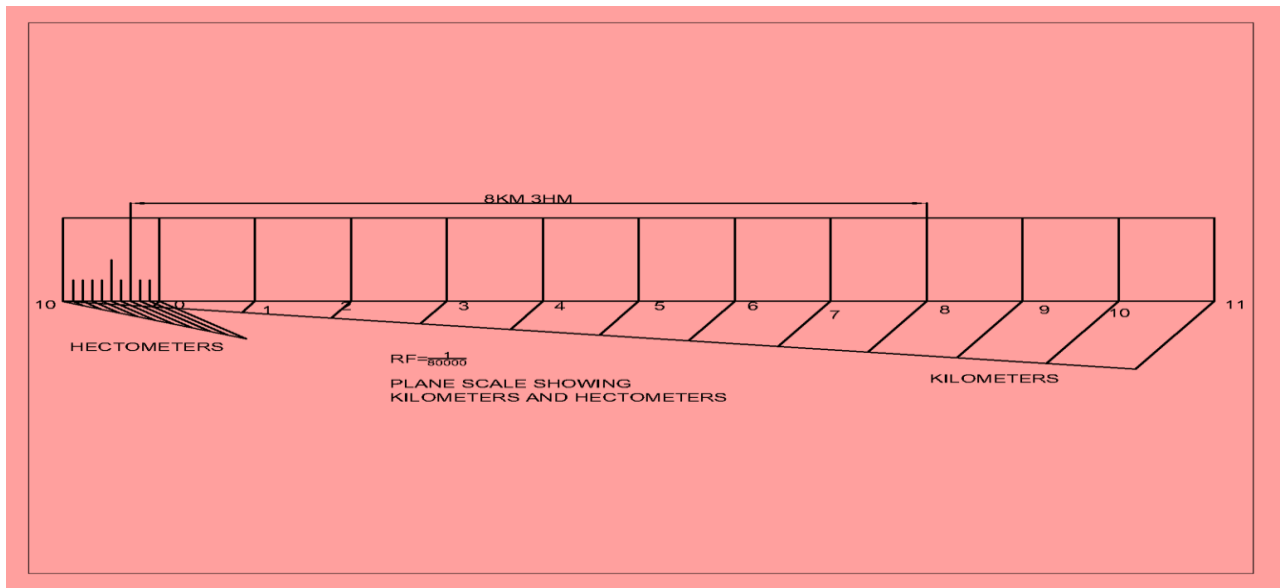


Fig 3.7

Q. No. 3.

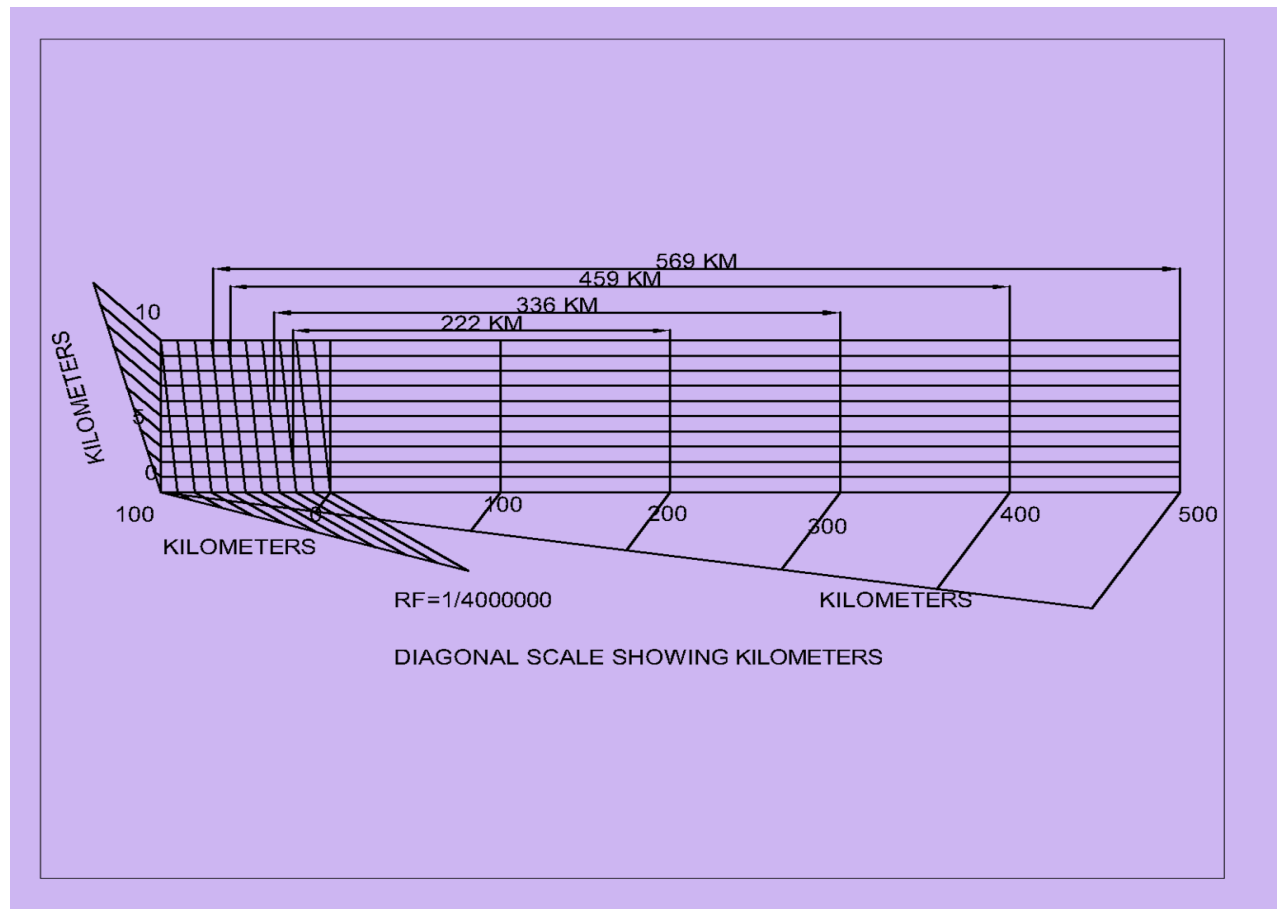
The distance between Delhi and Agra is 200 km. In a railway map it is represented by a line 5 cm long. Find it's R.F. Draw a diagonal scale to show single km. And maximum 600 km. Indicate on it following distances. 1) 222 km 2) 336 km 3) 459 km 4) 569 km

SOLUTION STEPS :

$$RF = 5 \text{ cm} / 200 \text{ km} = 1 / 40,000$$

$$\text{Length of scale} = (1 / 40,000) \times 600 \times 1000 = 15 \text{ cm}$$

- Draw a line 15 cm long. It will represent 600 km.
- Divide it in six equal parts. Each will represent 100 km.
- Divide first division in ten equal parts. Each will represent 10 km.
- Draw a line upward from left end and mark 10 parts on it of any distance.
- Name those parts 0 to 10 as shown in Fig 3.8.
- Join 9th sub-division of horizontal scale with 10th division of the vertical divisions. Then draw parallel lines to this line from remaining sub divisions and complete diagonal scale.



(Fig 3 .8)

Q. No. 4.

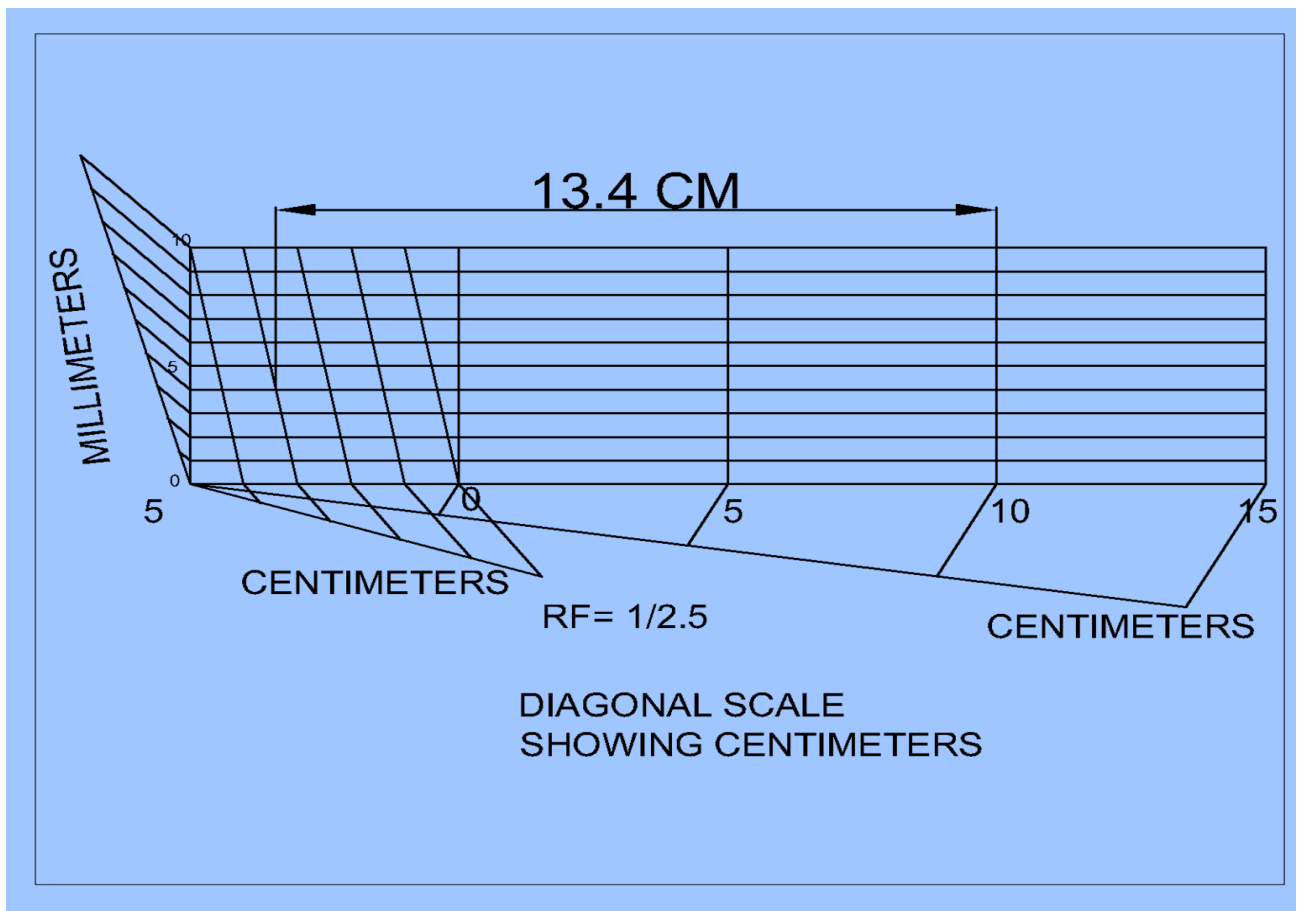
Draw a diagonal scale of R.F. 1: 2.5, showing centimeters and millimeters and long enough to measure up to 20 centimeters. Show the distance of 13.4 cm in it.

SOLUTION STEPS:

$$\text{R.F.} = 1 / 2.5$$

$$\text{Length of scale} = (1 / 2.5) \times 20 \text{ cm} = 8 \text{ cm.}$$

1. Draw a line 8 cm long and divide it in to 4 equal parts. (Each part will represent a length of 5cm.)
2. Divide the first part into 5 equal divisions. (Each will show 1 cm).
3. At the left hand end of the line, draw a vertical line and on it step-off 10 equal divisions of any length.
4. Complete the scale as explained in previous problems. Show the distance 13.4 cm on it in Fig3.9.



(Fig 3.9)

EXERCISES

1. Construct a diagonal scale to measure kilometers, hectometers, and decameters and long enough to measure 4Km, when a distance of 0.25km is represented by one centimeter on map. Find RF of the scale and also the length of the diagonal scale. Indicate on the scale a distance of RF of the scale and also the length of the diagonal scale. Indicate on the scale a distance of
 - a. 3 KM, 6 hectometer and 3 decameter.
 - b. 2 KM, 3 hectometers and 8 decameters
2. Construct a diagonal scale of R.F.= $1/6250$ to read up to 1km and to read meters on it. Show a length of 653m on it.
3. If the distances between two towns is 600km and it is represented on map by 12cm. Construct a diagonal scale to measure up to a single kilometers. Measure a distance of 349km, 417km and 495km on the map. Also find the R.F.
4. The distance between Kolkata to Puri is 560 Km which is represented by 14 cm on a map. Find the R.F. of the scale used for drawing the map. Construct a diagonal scale to show distance up to 800 Km and show a distance of 666 Km on it.
5. Construct a diagonal scale to read kilometres and decametres, given that 1 Km is represented by 5 cm on the drawing. Mark a distance of 3.47 Km on the scale.
6. Construct a diagonal scale to read metre ,decimeter and centimeter and long enough to measure up to 5 metres, when 1 metre is represented by 3c.m. Find the R.F and indicate on the scale distance of 4metre 7decimeter 6centimetre and 2metre 4decimetre 8 centimetre.
7. Draw a plane scale to show metre and decimeters when 1 metre is represented by 2.5cm on the scale. The scale should be long enough to measure up to 6m . Mark a distance of 4metre and 6decimetre on the scale.

CHAPTER – 4

CURVES

4.1 CONIC SECTIONS

Cone is formed when a right angled triangle with an apex and angle θ is rotated about its altitude as the axis. The length or height of the cone is equal to the altitude of the triangle and the radius of the base of the cone is equal to the base of the triangle. The apex angle of the cone is 2θ . When a cone is cut by a plane, the curve formed along the section is known as a conic section.

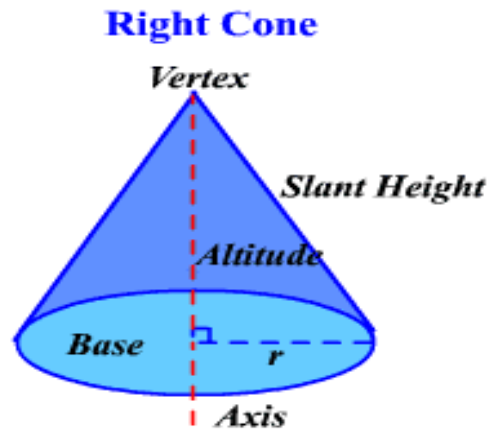


Fig 4.1

Following are some important conic sections.

1. Circle
2. Ellipse
3. Parabola
4. Hyperbola

4.1.1 CIRCLE :

When a cone is cut by a section plane A-A making an angle $\alpha = 90^\circ$ with the axis, the section obtained is a circle.

4.1.2 ELLIPSE :

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

4.1.3 PARABOLA :

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

side of the cone.

4.1.4 HYPERBOLA:

If the angle α is less than θ (section plane D-D), the curve at the section is hyperbola. The curve of intersection is hyperbola, even if $\alpha = \theta$, provided the section plane is not passing through the apex of the cone. However if the section plane passes through the apex, the section produced is an isosceles triangle.

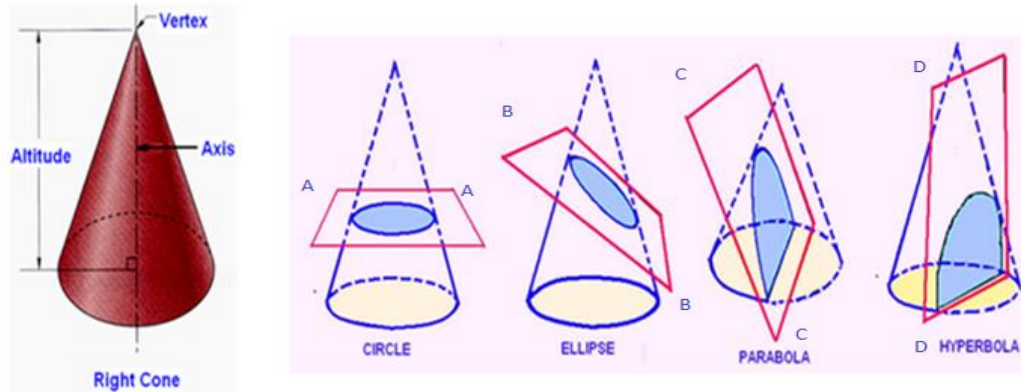


Fig 4.2

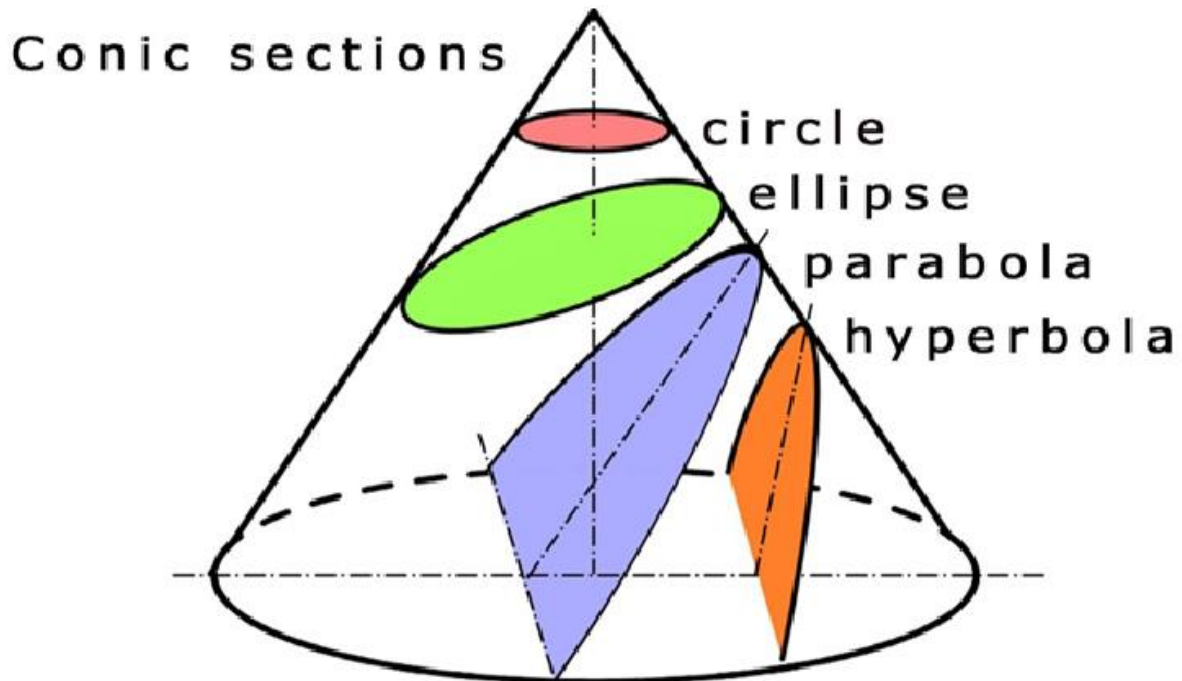


Fig 4.3

4.2 SOME IMPORTANT DEFINITIONS:

4.2.1 Major axis : It is the longest distance which passes through the centre, at right angle to the fixed lines called the directrix. AB is the major axis.

4.2.2 Minor axis : It is the maximum distance which bisects the major axis at right angle. It will be parallel to the directrix. CD is the minor axis.

4.2.3 Directrix : It is a straight line perpendicular to the major axis.

4.2.4 Focus: When an arc is drawn with C or D as centre and radius equal to half of the major axis i.e. $AB/2$ it is cut at two points F_1 and F_2 on the major axis. F_1 and F_2 are the focal points of an ellipse F_1 or F_2 is the focus. The sum of the distances from F_1, F_2 to any point on the curve i.e., $F_1P + F_2P$ is always constant and equal to the major axis.

4.2.5 Focal radii : The distances from point P on the curve to the focal points F_1 and F_2 are called focal radii. Sum of the focal radii is equal to the major axis.

4.2.6 Eccentricity: The ratio between the distances from the vertex to focus and vertex to the directrix is called the eccentricity.

- a. If $e=1$, it is parabola
- b. If $e>1$, it is hyperbola
- c. If $e<1$, it is an ellipse

4.2.7 Vertex : The end points of the major axis on the curve are called vertex. (A, B)

4.2.8 Tangent and normal to an ellipse : Normal is the line bisecting the angle $F_1 P F_2$ in Fig 4.

Tangent is a line at 90° to the normal and touching the ellipse.

Directrix, axis, focus, vertex and tangent are the elements common to ellipse, parabola and hyperbola.

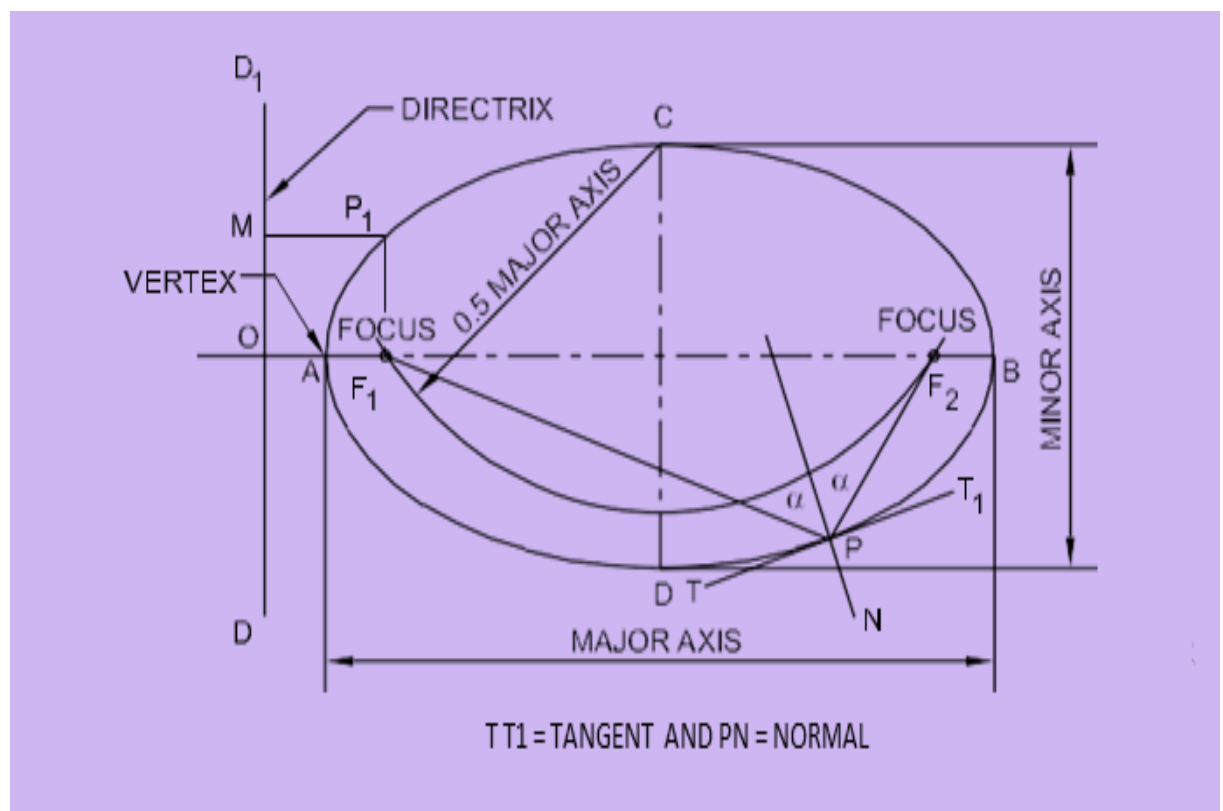


Fig 4.4

Q. No. 1.

To draw a parabola with the distance of the focus from the directrix at 60mm (Eccentricity method)

Construction :

Draw the directrix AB and the axis CC' at right angles to it:

Mark the focus F on the axis at 60 mm.

Locate the vertex V on CC' such that $CV = VF$

Draw a line VB perpendicular to CC' such that $VB = VF$

Join C, B and extend. Now, $VF / VC = 1$, the eccentricity.

Locate number of points 1, 2, 3,, on VC' and erect perpendiculars through them meeting CB produced at 1',2',3'.....

With F as a centre and radius equal to 1-1' cut two arcs on the perpendicular through 1 to locate P1 and P1'. Similarly with F as center and radius 2-2', 3-3' etc cut arcs on the corresponding perpendiculars to locate P2 and P2', P3 and P3' etc.

Draw a smooth curve passing through V,P1, P2, P3....P3',P2',P1'.

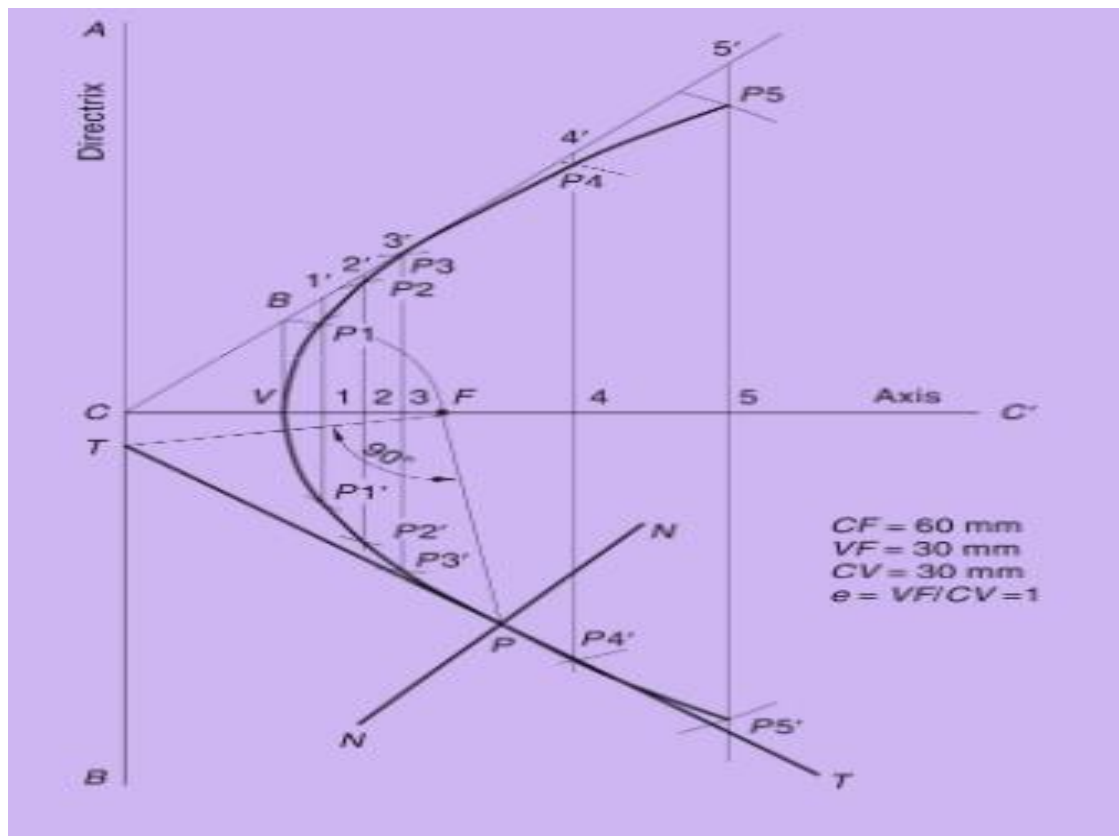


Fig 4.5

All dimensions are in mm

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

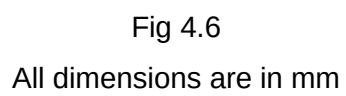
To draw a tangent and normal to the parabola. locate the point P which is at 40 mm from the directrix. Then join P to F and draw a line through F, perpendicular to PF to meet the directrix at T. The line joining T and P and extended is the tangent and a line NN, through P and perpendicular to TP is the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

Q. No. 2.

To draw an ellipse with the distance of the focus from the directrix at 50mm and eccentricity = $\frac{2}{3}$ (Eccentricity method).

Construction :

1. Draw any vertical line AB as directrix and mark appoint C on it.
2. Draw a horizontal line CD of any length from point C as axis.
3. Mark a point F on line CD at 50mm from C.
4. Divide CF in 5 equal divisions.
5. Mark V on 2nd division from F.
6. Draw a perpendicular on V and mark a point E on it at a distance equal to VF.
7. Join CE and extend it.
8. Mark points 1,2,3.....on CF beyond V at uniform distance and draw perpendiculars on each of them so as to intersect extended CE at 1',2',3'.....



Q. No. 3.

To draw a hyperbola with the distance of the focus from the directrix at 50mm and $e=3/2$ (Eccentricity method).

Construction :

1. Draw the directrix AB and the axis CC'.
2. Mark the focus F on CC' and 50mm from C.
3. Divide CF into 5 equal divisions and mark V the vertex, on the second division from C.
4. Draw a line VE perpendicular to CC' such that VE=VF. Join C and E.
5. Mark any point 1 on the axis and through it, draw a perpendicular to meet CE produced at 1'.
6. With centre F and radius equal to 1-1', draw arcs intersecting the perpendicular through 1 at P1 and P1'.

Similarly mark a number of points 2, 3 etc and obtain points P2 and P2', etc.

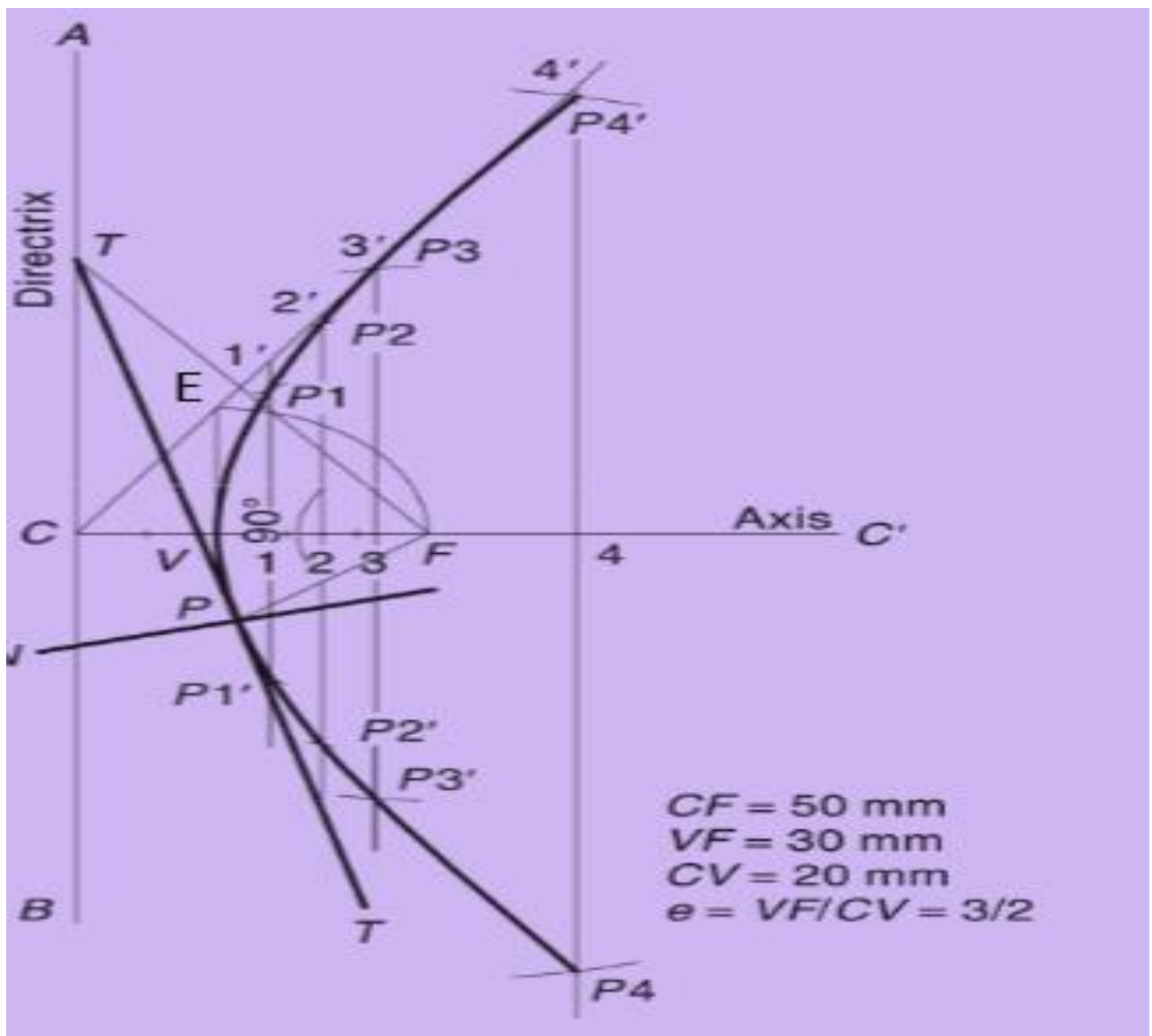


Fig 4.7 All dimensions are in mm

Q. No. 4.

Construct an ellipse by concentric circle method. Major axis 80 mm. Minor axis 40 mm.

Construction :

1. Draw the major axis AB(80mm) and minor axis CD (40mm), bisecting at right angle at O.
2. CD (40mm), bisecting at right angle at O.
3. 'O' as centre OA and OC as radius, draw two concentric circles.
4. Draw a number of radial lines through 'O' (say 12) cutting the two circles.
5. Mark the points on the outer circle as a, b, c.
6. Similarly mark the corresponding intersecting points on inner circle as a', b', c'.
7. From points such as a, b, c...draw lines parallel to minor axis.
8. From points such as a', b', c' draw lines parallel to the major axis to intersect with the corresponding vertical lines at points P_1, P_2, P_3 etc.
9. Join all these points with a smooth curve by free hand or using "French curve" and form the ellipse.

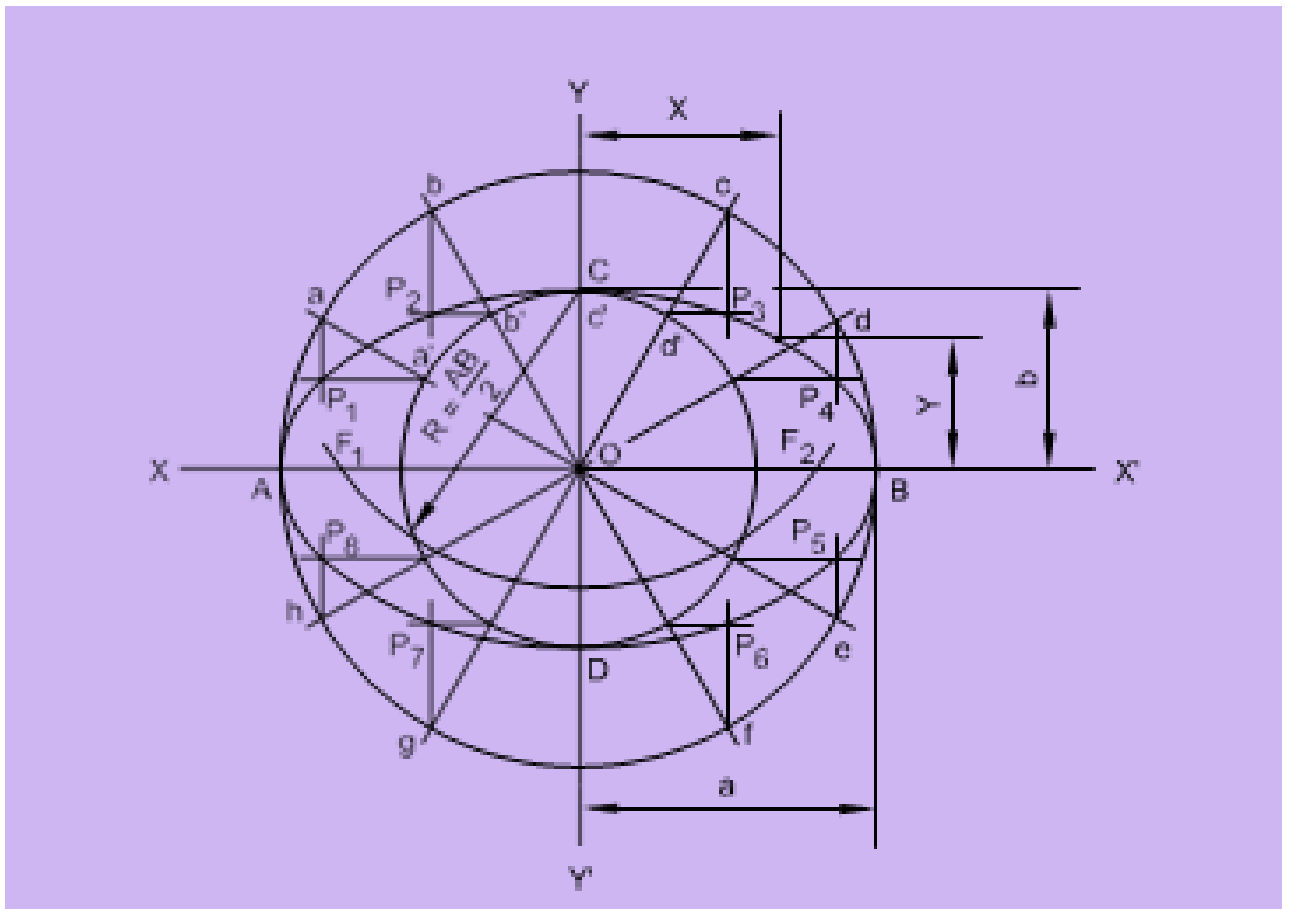


Fig 4.8

All dimensions are in mm

Q. No. 5.

The foci of an ellipse are 90 mm apart and its minor axis is 65 mm. Find major axis and construct ellipse by arcs of circle method.

Construction :

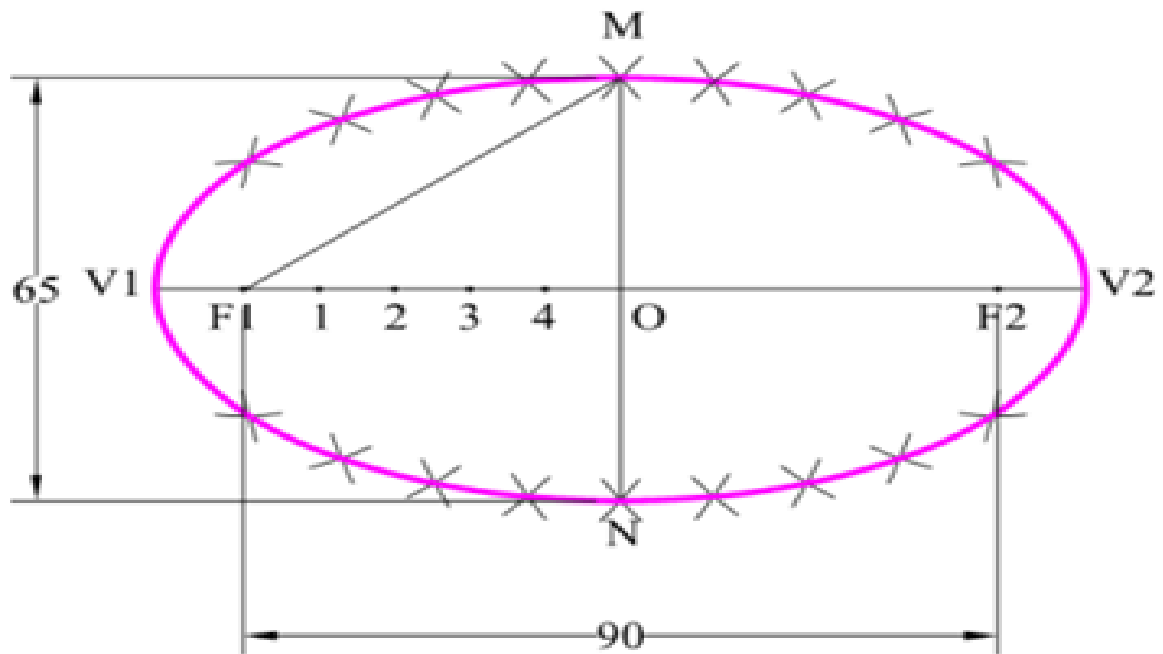


Fig 4.9

All dimensions are in mm

1. Draw a horizontal line. Mark F1 and F2 such that distance between F1 and F2 is 90 mm (Focal distance). Mark midpoint of F1-F2 as 'O'.
2. Draw vertical line through 'O' and mark MN (minor axis = 65mm) such that OM = ON = 32.5 mm.
3. We know $MF1 = OV1 = OV2$. Take distance in compass equal to MF1 and mark points V1 and V2 by taking center as 'O'. V1-V2 is major axis.
4. Mark 4 to 5 points randomly between F1 and O. Name the points as 1, 2, 3, 4.
5. Take distance in compass equal to V1-1 and by taking center F1 mark arcs above and below the major axis. With same distance and taking center F2 mark arcs above and below the major axis.
6. Take distance in compass equal to V2-1 and by taking center F1 mark arcs to cut previous arcs. With same distance and taking center F2 mark arcs to cut previous arcs.
7. Repeat the procedure for all remaining points 2, 3, 4 and also for 'O'.
8. Draw a smooth curve passing through all points and end of major axis.

Q. No. 6.

Draw a parabolic arc with a span of 1000 mm and a rise of 800 mm. Use the rectangular method.

Construction :

1. Draw an enclosing rectangle ABCD with base AB = 1000 mm and height BC = 800 mm using a suitable scale;
2. At its mid-point E, draw the axis EF at right angle to AB;
3. Divide AE and AD into the same of equal parts and label them, say 1, 2, 3 and 1', 2', 3' etc;
4. Draw lines joining F with points 1, 2 and 3. Through 1', 2', and 3', draw perpendiculars to AB intersecting F1, F2 and F3 at points P_1 , P_2 and P_3 respectively;
5. Draw a curve through A, P_1 , P_2 etc. It will be a half parabola.

Repeat the same construction in the other half of the rectangle to complete the parabola. Or, locate the points by drawing lines through the points P_1 , P_2 etc. parallel to the base and making each of them of equal length on both the sides of EF, e.g. $P_1O = O P_1'$. AB and EF are called the base and the axis respectively of the parabola. See Fig. given below.

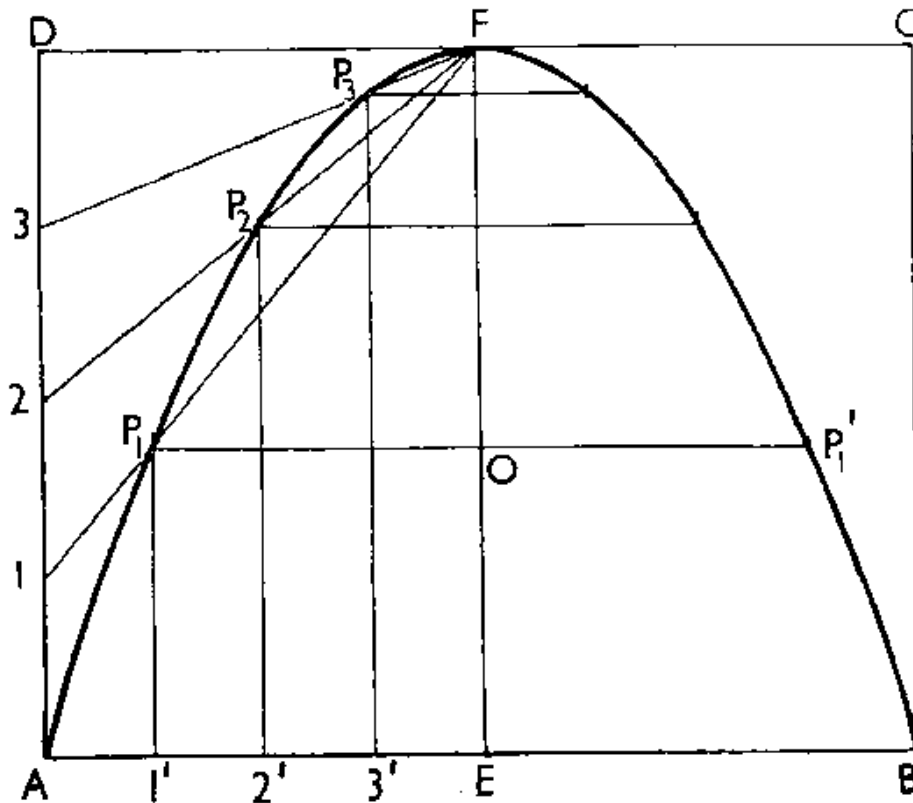


Fig 4.10

All dimensions are in mm

Q. No. 7.

To draw a parabola using the tangent method with 70 mm as base and 30 mm as the length of the axis.

Construction :

1. Draw the base AB and locate its mid-point C.
2. Through C, draw CD perpendicular to AB forming the axis
3. Produce CD to E such that $DE = CD$
4. Join E-A and E-B. These are the tangents to the parabola at A and B.
5. Divide AE and BE into the same number of equal parts and number the points as shown.
6. Join 1-1', 2-2', 3-3', etc., forming the tangents to the required parabola.
7. A smooth curve passing through A, D and B and tangential to the above lines is the required parabola.

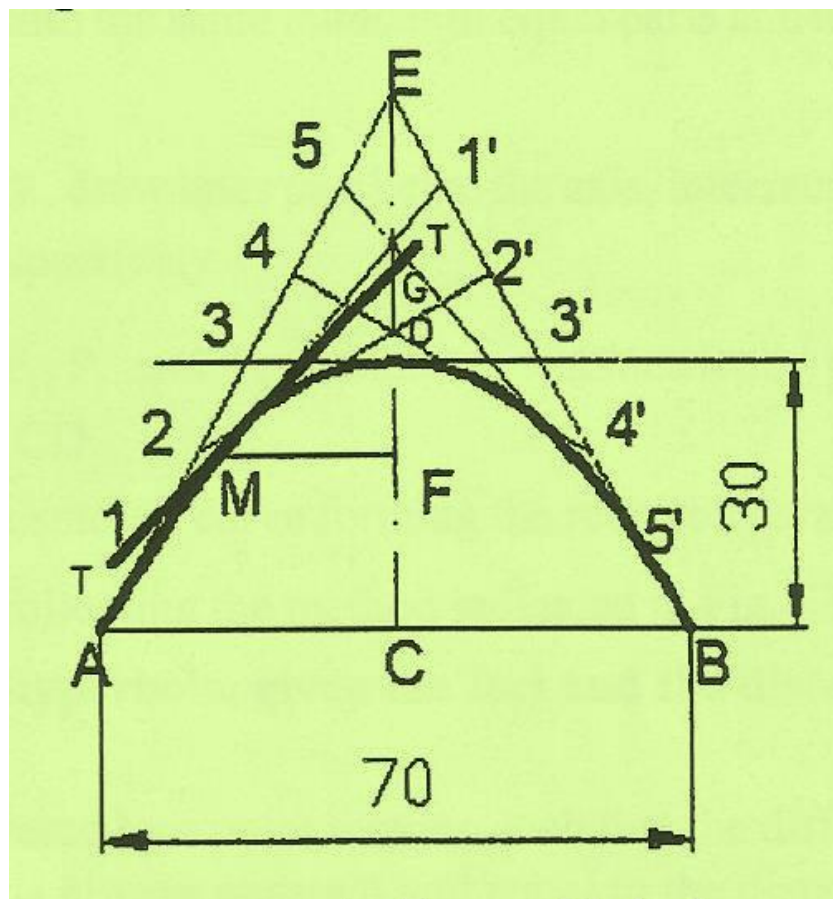


Fig 4.11

All dimensions are in mm

EXERCISES

1. Construct a conic when the distance of its focus from the directrix is equal to 50 mm and its eccentricity is $\frac{3}{4}$. Measure its major and minor axes. Draw a tangent at any point on the curve. What is the distance between the foci.
2. The major and minor axes of an ellipse are 80 mm and 50 mm respectively. Construct the curve.
3. Draw an ellipse whose major and minor diameters are 150 mm and 100 mm respectively. Use concentric circle method.
4. Draw a parabola whose focus is at a distance of 50 mm from the directrix. Draw a tangent and normal at any point on it.
5. Construct a parabola if the distance between its focus and directrix is 60 mm. Also draw a tangent to the curve.
6. Construct an ellipse with major axis and minor axis measuring 120 mm & 70 mm respectively by rectangular or box method.
7. Construct an ellipse, with a distance of the focus from the directrix as 60 mm and eccentricity as $\frac{2}{3}$. Also draw normal and tangent to the curve at a point 40 mm from the directrix.
8. Construct a parabola whose base is 90 mm and axis is 80 mm using the following methods:
 - a. Rectangular method
 - b. Tangent method

CHAPTER – 5

ORTHOGRAPHIC PROJECTION

5.1 PRINCIPLES OF FIRST ANGLE PROJECTION AND THIRD ANGLE PROJECTION

5.1.1 INTRODUCTION

A projection may be defined as a representation of an object on a two dimensional plane. It is obtained by drawing straight lines from various on the contour of an object is said to be projected on that plane. The figure formed by joining in correct sequence, the points at which these lines meet the plane is called the projection of the object. The lines which are drawn from the object to the plane are called projectors. Following are the elements to be considered while obtaining a projection.

- a. Object
- b. Plane of projection
- c. Point of sight
- d. Rays of sight

5.1.2 TYPES OF PROJECTION

Following are the methods of projection are commonly used in engineering practice.

- a. Orthographic projection
- b. Isometric projection
- c. Oblique projection
- d. Perspective projection

5.1.3 ORTHOGRAPHIC PROJECTION

Orthographic Projections is a technical drawing in which different views of an object are projected on different reference planes observing perpendicular to respective reference plane.

5.1.4 DEFINITION OF SOME TERMS IN ORTHOGRAPHIC PROJECTION

- i. **Horizontal Plane (H.P)** : It is the plane which is horizontal and at right angle to the vertical plane. The top view or plan of the object is projected on this plane. It is generally denoted in short form as H.P.
- ii. **Vertical plane (V.P)**: It is the plane which is perpendicular to the horizontal plane and is also known as frontal plane because the front view or elevation of the object is projected on this plane. It is generally denoted by V.P. The V.P and H.P. are called principal planes.
- iii. **Auxiliary plane (A.P)** : Any other plane which is placed at any angles to te principal plane i.e. H.P. and V.P. is called auxiliary plane.
- iv. **Reference line**: The line of intersection of two principal planes of projection i.e. V.P and H.P. is called reference or ground or intersection line. It is generally denoted by X-Y line.

- v. **Elevation** : The projection of the object on the vertical plane (V.P) is called elevation or Front View (F.V). Front View of the object is taken while looking at the object from its front.
- vi. **Plan** : Plan or top view (T.V) of the object is taken while looking at the object from its top. The plan or top view is projected on the horizontal Plane (H.P).
- vii. **Side view or End View** : Projection of the object on an auxiliary plane (A.P) or auxiliary vertical plane (AVP) is known as side view or end view or profile view or side elevation.
- viii. **Auxiliary View** : The projection of the object on an auxiliary plane is known as auxiliary view (A.V).

5.1.5 FOUR QUADRANTS

The object may be situated in any of the four quadrants , its position relative to the planes being described as above or below the H.P and in front of or behind the V.P. In INDIA generally the first angle projection is adopted for drawing works but in countries like U.S.A, Canada, U.K etc third angle projection is adopted for normal drawing work .

The position of the object placed in any of the quadrant is described as under in Fig 5.1

Object placed in 1st Quadrant: Above H.P and in front of V.P.

Object placed in 2nd Quadrant: Above H.P and behind V.P.

Object placed in 3rd Quadrant: Below H.P and behind V.P.

Object placed in 4th Quadrant : Below H.P and in front of V.P.

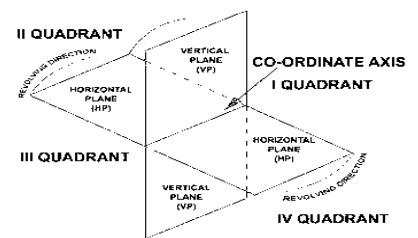


Fig 5.1

5.1.6 FIRST ANGLE PROJECTION :

If the object is situated in the first quadrant i.e above H.P and in front of V.P. , the projection of the object so obtained is known as First Angle projection. Symbol of the First Angle projection is denoted by Fig 5.2.

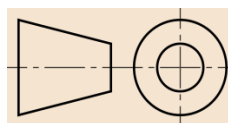


Fig 5.2

5.1.7 THIRD ANGLE PROJECTION :

If the object is situated in the third quadrant i.e below H.P and in behind V.P. The projection of the object so obtained is known as third Angle projection. Symbol of the Third Angle projection is denoted by Fig 5.3

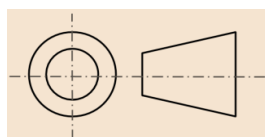


Fig 5.3

5.2 PROJECTION OF POINTS :

5.2.1 INTRODUCTION

A point may be defined as a line having zero length or it also may be defined as a circle having zero diameter. It has no size and dimensions.

5.2.2 SOLVED PROBLEMS

Q. No. 1.

Draw the orthographic projections of the Point P which is 30 mm above H.P and 40 mm in front of V.P.

Solution :

- As the point is above H.P. and in front of V.P.; so it is in 1st quadrant.
- Draw a line XY (Reference Line) which is the intersection line of HP and VP.
- As 'P' is 30mm above H.P.', its front view "p'" is 30 mm XY.
- 'P' is 40 mm in front of VP , its top view 'p' is 40 mm from XY.
- Draw the projector pp' as shown in figure.

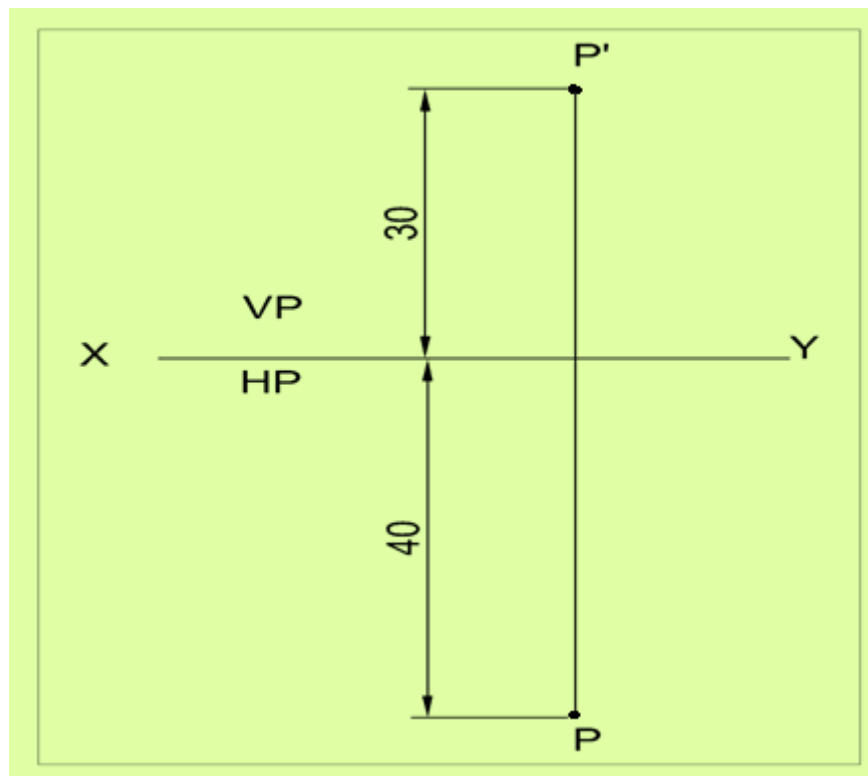


Fig 5.4

All dimensions are in mm

NOTE : Front view of the points are denoted by small letters with an apostrophic symbol and top views are specified by small letters only. For e.g. for a point A in space the front view and top view are represented by a' and a respectively.

Q. No. 2.

Draw the orthographic projections of the Point Q which is 25 mm above H.P and 35 mm behind VP

Solution :

- As the point is above H.P. and behind V.P.; so it is in 2nd quadrant.
- Here both the views (top and front) will be obtained above the reference line XY, Hence the H.P. will coincide with V.P.
- Draw a reference line XY. Mark a point 'q' 25mm above XY which is the front view and another point 'q'' 35mm from XY which is the top view as shown in figure.

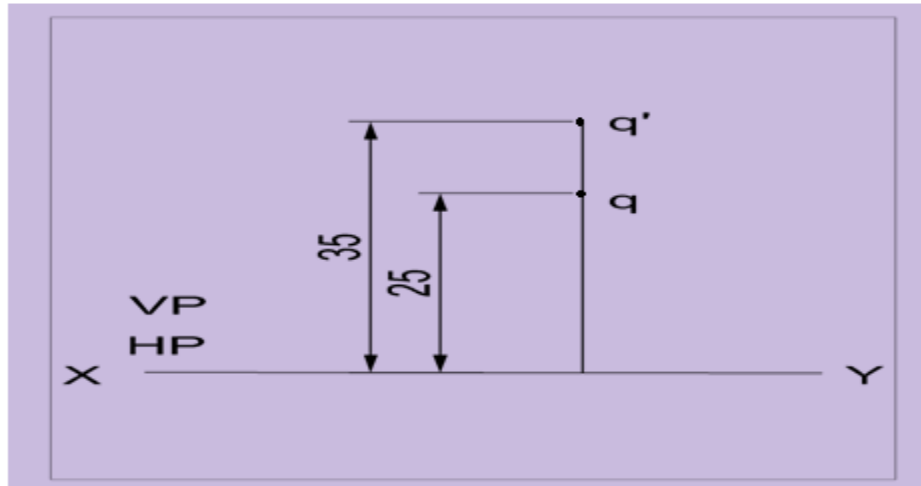


Fig 5.5

All dimensions are in mm

Q. No. 3.

Draw the orthographic projections of the Point R is 32 mm. below H.P and 45 mm behind VP

Solution :

- As the point is below H.P. and behind V.P.; so it is in 3rd quadrant.
- Here the front and top view will be obtained on VP and HP assuming VP is transparent.
- Draw the reference line XY. Mark the front view at a distance 32 mm below XY and top view at a distance 45 mm above XY as shown.

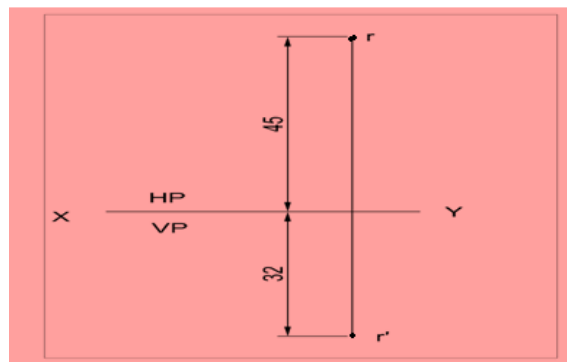


Fig 5.6

All dimensions are in mm

Q. No. 4.

Draw the orthographic projections of the Point S is 35 mm. below H.P and 42 mm in front of VP

Solution :

- As the point is below H.P. and in front of V.P.; so it is in 4th quadrant.
- Here both the views will lie below the reference line as the H.P. coincides with V.P. as shown.
- Draw the reference line XY. Mark the front view and top view at a distance of 20mm and 30 mm respectively from XY on the same projector.

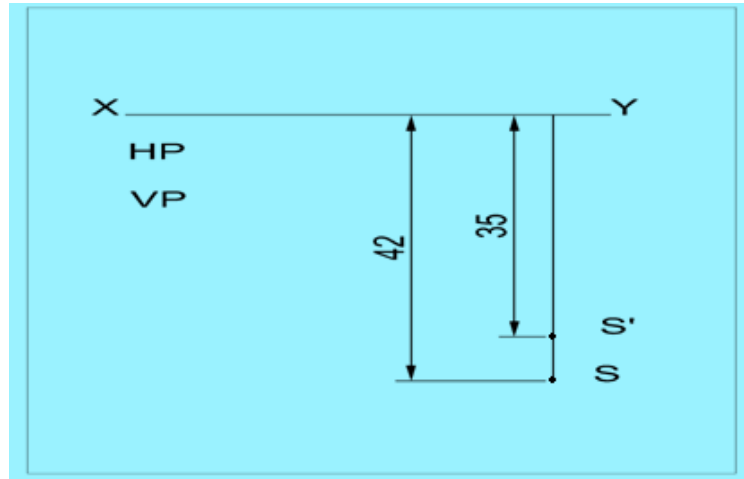


Fig 5.7

All dimensions are in mm

Q. No. 5.

Draw the orthographic projections of the Point T is in H.P and 30 mm behind VP

Solution :

- As the point is in H.P. and behind V.P.; so it is in H.P.
- Here side view will be on VP and top view 30mm behind VP.
- Draw the reference line XY. Mark the front view at any point on XY and top view at a distance of 30 mm from XY on the same projector.

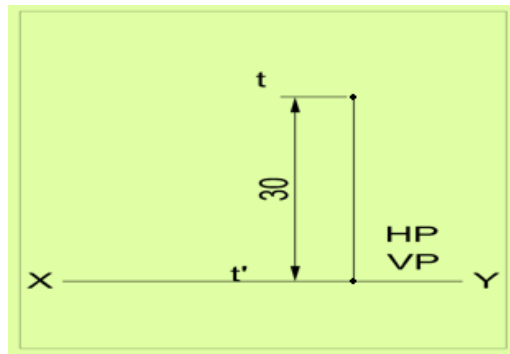


Fig 5.8

All dimensions are in mm

Q.No. 6.

Draw the orthographic projections of the Point U is in V.P and 40 mm. below HP

Solution :

- i. As the point is in V.P. and below H.P.; so it is in V.P.
- ii. Here side view will be on VP and top view 40 mm. below HP.
- iii. Draw the reference line XY. Mark the top view at any point on XY and side view at a distance of 40 mm from XY on the same projector.

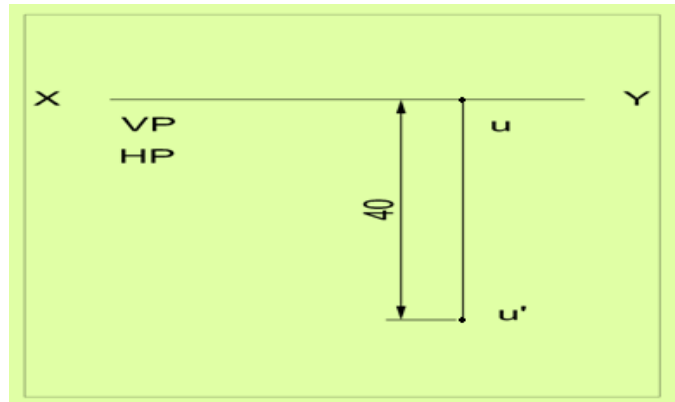


Fig 5.9

All dimensions are in mm

Q. No. 7.

Draw the orthographic projections of the Point V is in V.P and 35 mm. above H.P

Solution :

- i. As the point is in V.P. and above H.P.; so it is in V.P.
- ii. Here side view will be on VP and top view on HP.
- iii. Draw the reference line XY. Mark the top view at any point on XY and side view at a distance of 35 mm from XY as shown in fig 5.10.

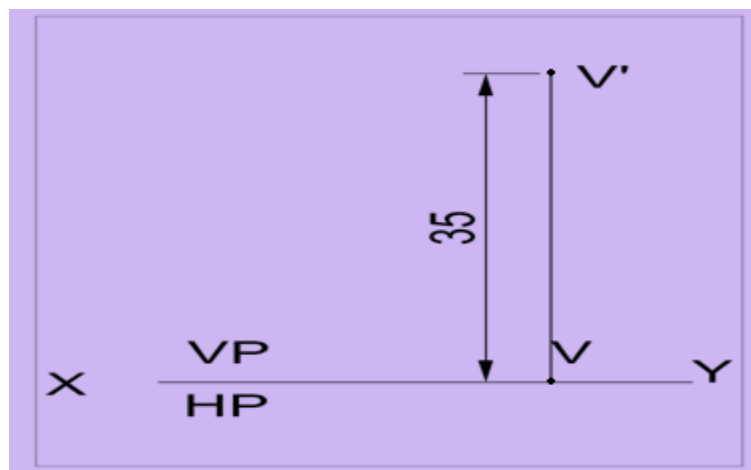


Fig 5.10

All dimensions are in mm

Q. No. 8.

Draw the orthographic projections of the Point W is in H.P and 48 mm. in front of VP

Solution :

- i. As the point is in H.P. and 48mm in front of V.P.; so it is in H.P.
- ii. Here side view will be on VP and top view on HP.
- iii. Draw the reference line XY. Mark the side view at any point on XY and top view at a distance of 48 mm from XY as shown in fig 5.11.

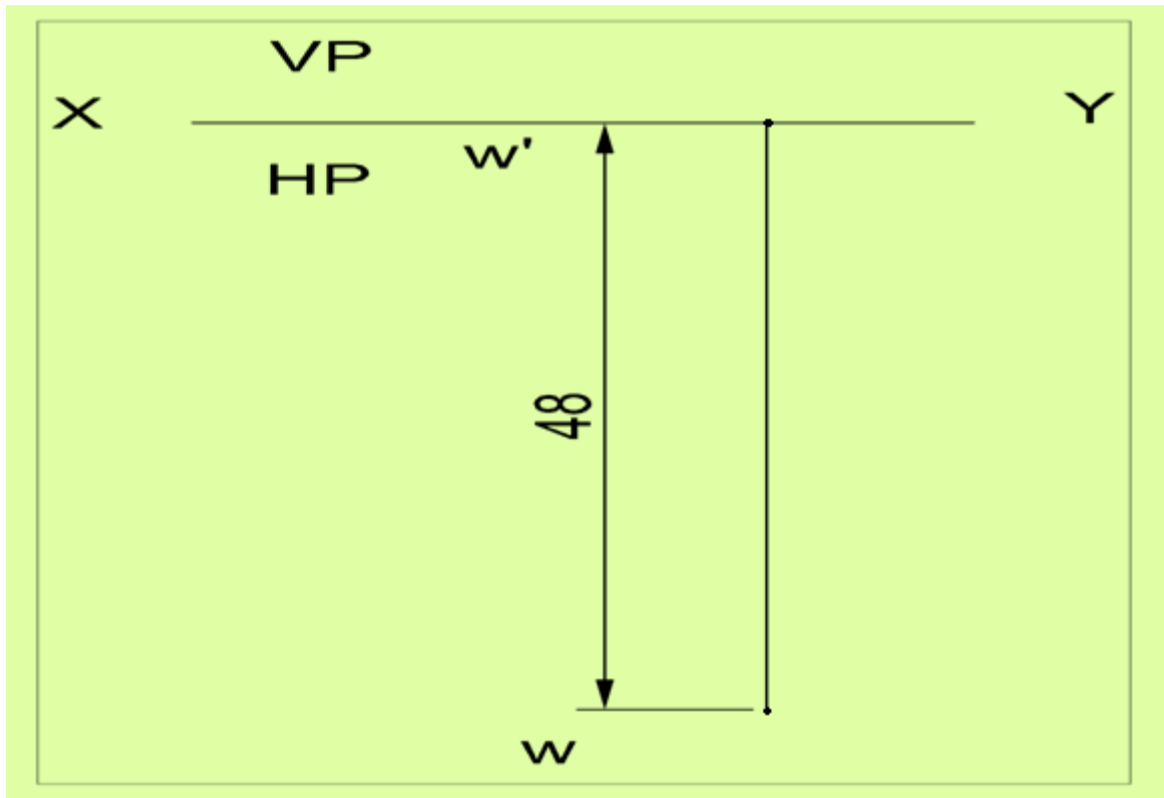


Fig 5.11

All dimensions are in mm

5.3 PROJECTION OF LINES :

5.3.1 INTRODUCTION

A straight line may be defined as the shortest distance between any two points. It may be generated by a point moving in one direction.

5.3.2 SOLVED PROBLEMS

Q. No. 1.

A 50mm long line AB is parallel to both H.P and V.P. The line is 25mm in front of V.P and 60mm above H.P, draw the projections of the line.

Solution :

- Draw reference axis XY.
- Mark the side view of the point A of the line AB i.e a' at a distance of 60mm above XY and " a " at 25mm below XY.
- Through a' and a draw lines $a'b'$ and ab parallel to XY of its true length 50mm.
- $a'b'$ and ab are the front view and top view of line AB respectively.

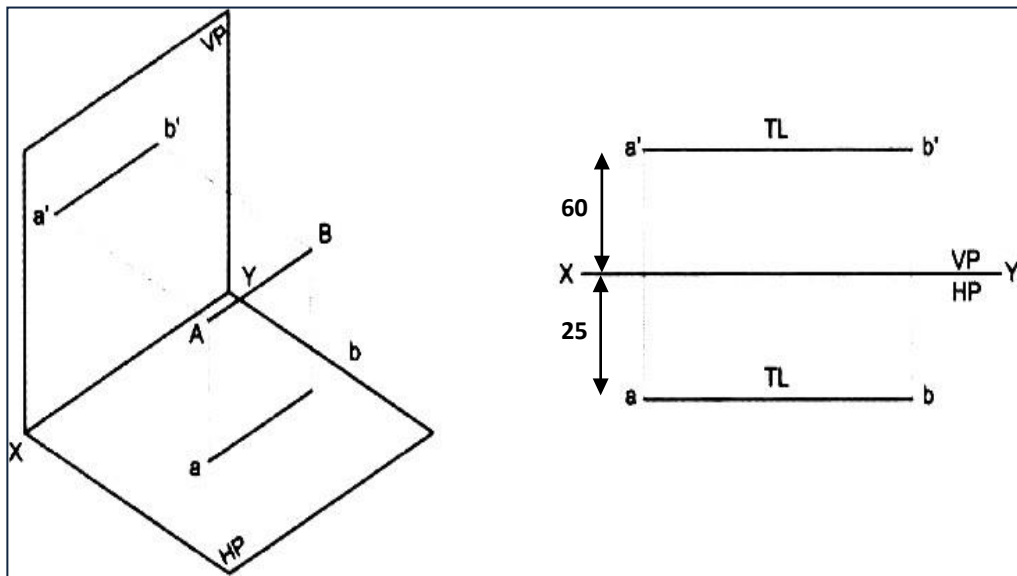


Fig 5.12

All dimensions are in mm

Q. No. 2.

A 60mm long line AB has its end A at a distance of 20mm above the H.P. The line is perpendicular to the H.P and 40mm in front of V.P, draw the projections of the line.

Solution :

- Draw reference axis XY.
- Mark the side view of the point A of the line AB i.e a' at a distance of 20mm above XY and top view " a " at 40 mm below XY.
- Through a' and a draw lines $a'b'$ of its true length 60mm. Point " a " will coincide with point " b " in its top view.
- $a'b'$ and $(a)b$ are the front view and top view of line AB respectively. Since point " a " is hidden, it is represented in brackets.

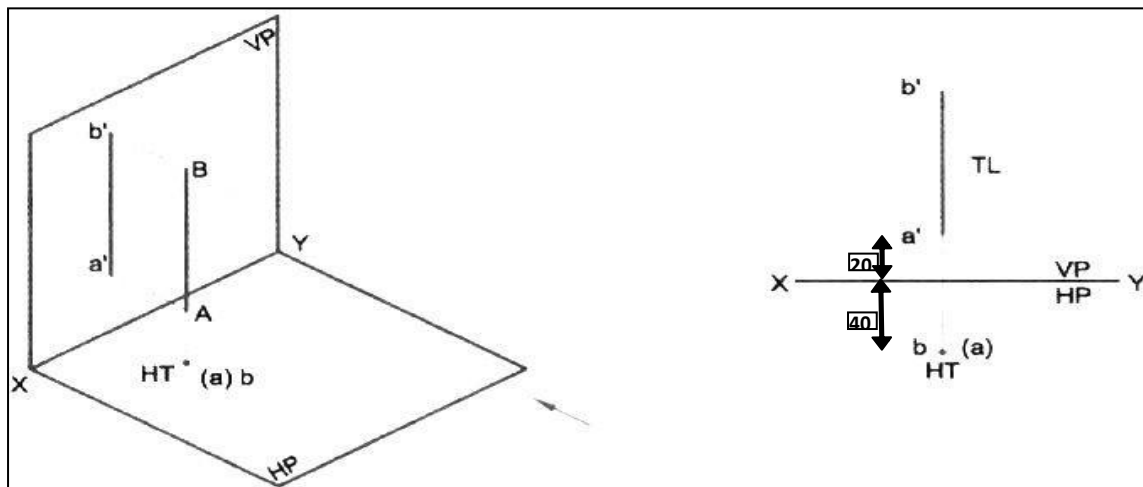


Fig 5.13

All dimensions are in mm

Q. No. 3.

A 60mm long line AB, has its end A at a distance of 20mm in front of the V.P. the line is perpendicular to V.P and 40mm above H.P, draw the projection of the line.

Solution :

- Draw reference axis XY.
- Mark the side view of the point B of the line AB i.e b' at a distance of 40mm above XY and top view " a " at 20mm below XY.
- Through " a " draw line ab of its true length 60mm in the direction perpendicular to XY. Point a' will coincide with point b' in its side view.
- $(a')b'$ and ab are the front view and top view of line AB respectively. Since point a' is hidden, it is represented in brackets.

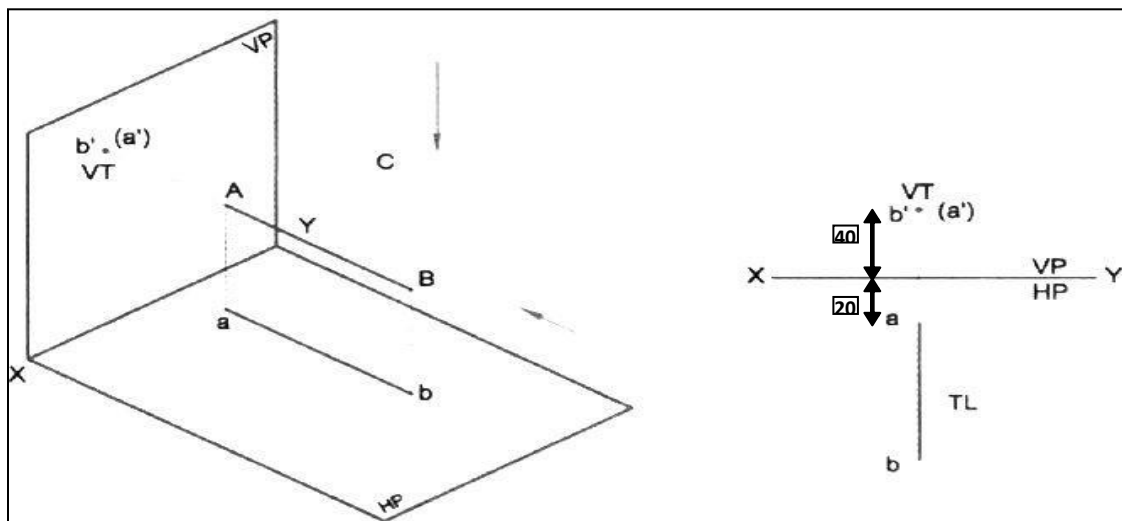


Fig 5.14

All dimensions are in mm

Q. No. 4.

A 80 mm long line AB has the end A at a distance of 20 mm above HP and 40mm in front of V.P. The line is inclined at 30° to H.P and parallel to V.P, draw the projection of the line.

Solution :

- i. Draw reference axis XY.
- ii. Mark the side view of the point A of the line AB i.e. a' at a distance of 20mm above XY and top view " a " at 40 mm below XY.
- iii. Through " a " draw line ab of its true length 80mm parallel to XY and through a' draw line $a'b'$ at an inclination of 30° to XY.
- iv. $a'b'$ and ab are the front view and top view of line AB respectively.

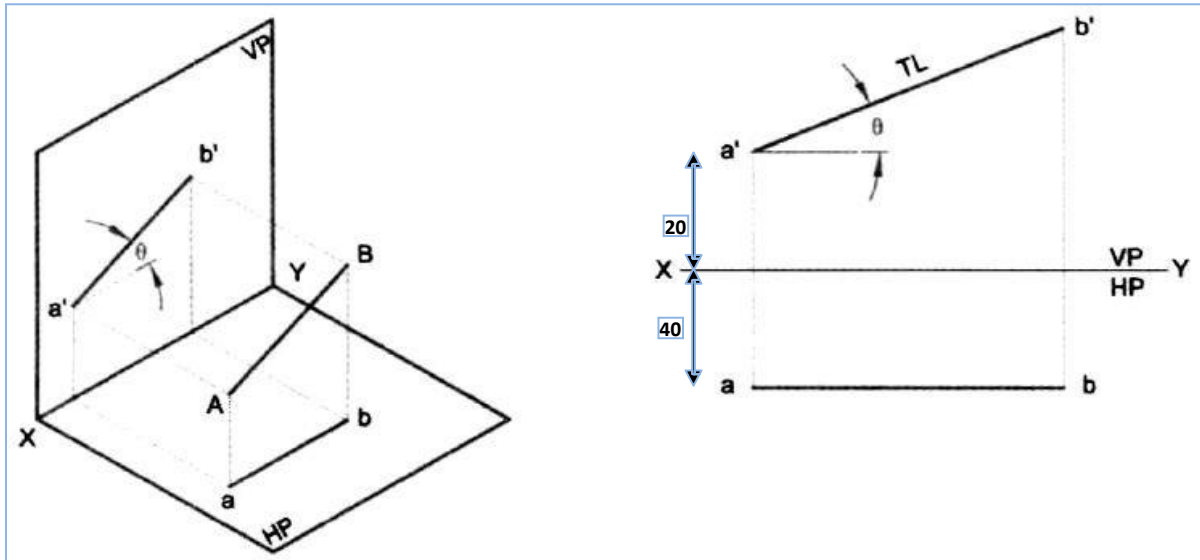


Fig 5.15

All dimensions are in mm

Q. No. 5.

A 80mm long line AB is inclined at 30° to V.P and is parallel to H.P. The end A is 20mm above the H.P and 20mm in front of the V.P, draw the projection of the line.

Solution :

- Draw reference axis XY.
- Mark the side view of the point A of the line AB i.e a' at a distance of 20mm above XY and top view " a " at 20 mm below XY.
- Through " a " draw line ab of its true length 80mm at an inclination of 30° to XY and through a' draw line $a'b'$ parallel to XY.
- $a'b'$ and ab are the front view and top view of line AB respectively.

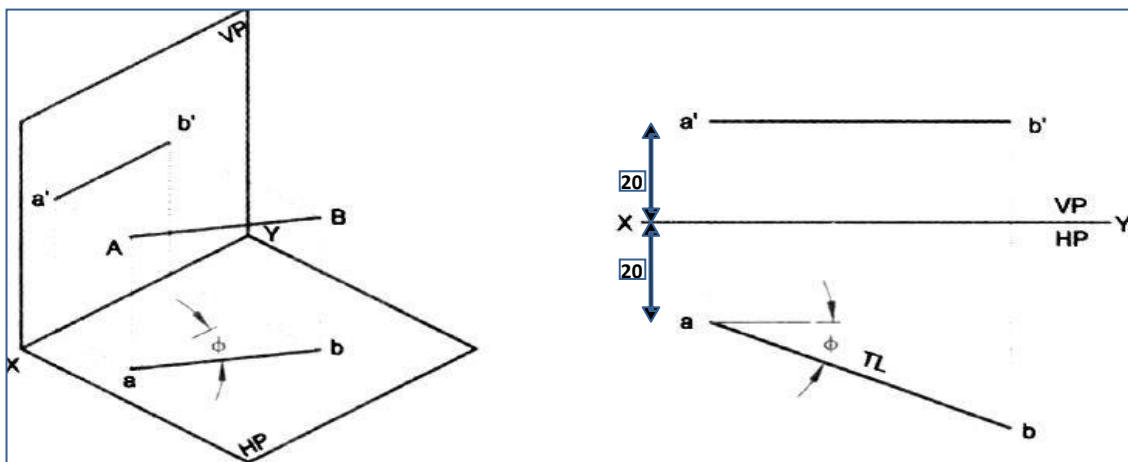


Fig 5.16 All dimensions are in mm

Q. No. 6.

A 70mm long line AB has an end A at 20 mm above H.P and 30 mm in front of V.P. The line is inclined at 45° to the H.P and 30° to V.P, draw the projections.

Solution :

- i. Draw reference axis XY.
- ii. Mark the side view of the point A of the line AB i.e a' at a distance of 20mm above XY and top view " a " at 30 mm below XY.
- iii. Through " a " draw line ab of its true length 70mm at an inclination of 30° to XY and through a' draw line $a'b'$ of it's true length 70mm at an inclination of 45° to XY.
- iv. $a'b'$ and ab are the front view and top view of line AB respectively

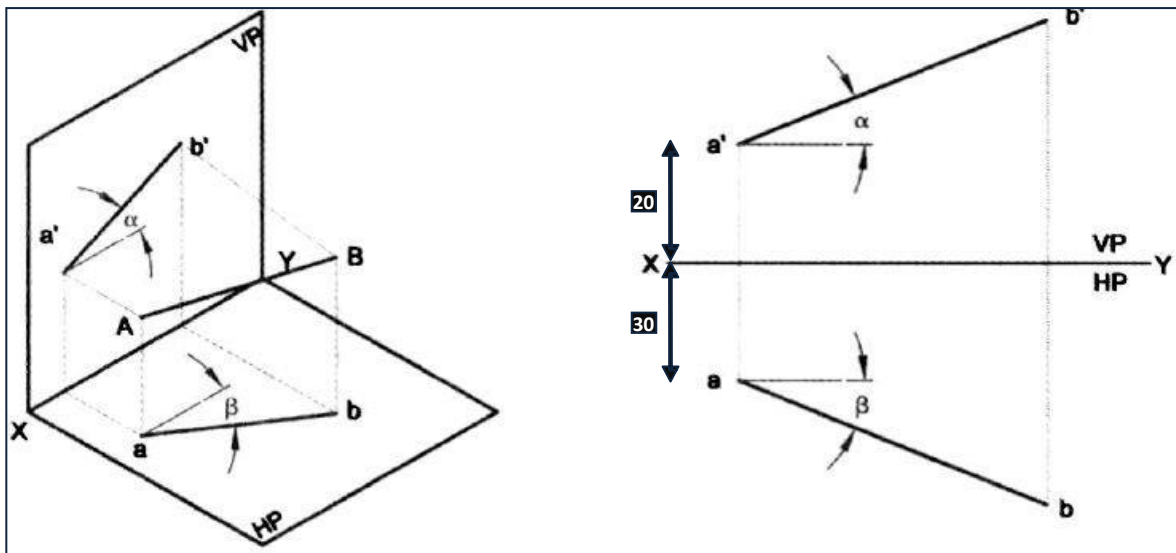


Fig 5.17
All dimensions are in mm

5.4 PROJECTION OF PLANES:

5.4.1 INTRODUCTION

A plane is a two-dimensional object having length and breadth only. Its thickness is always neglected; various shapes of plane figures are considered such as square, rectangle, circle, pentagon, hexagon etc.

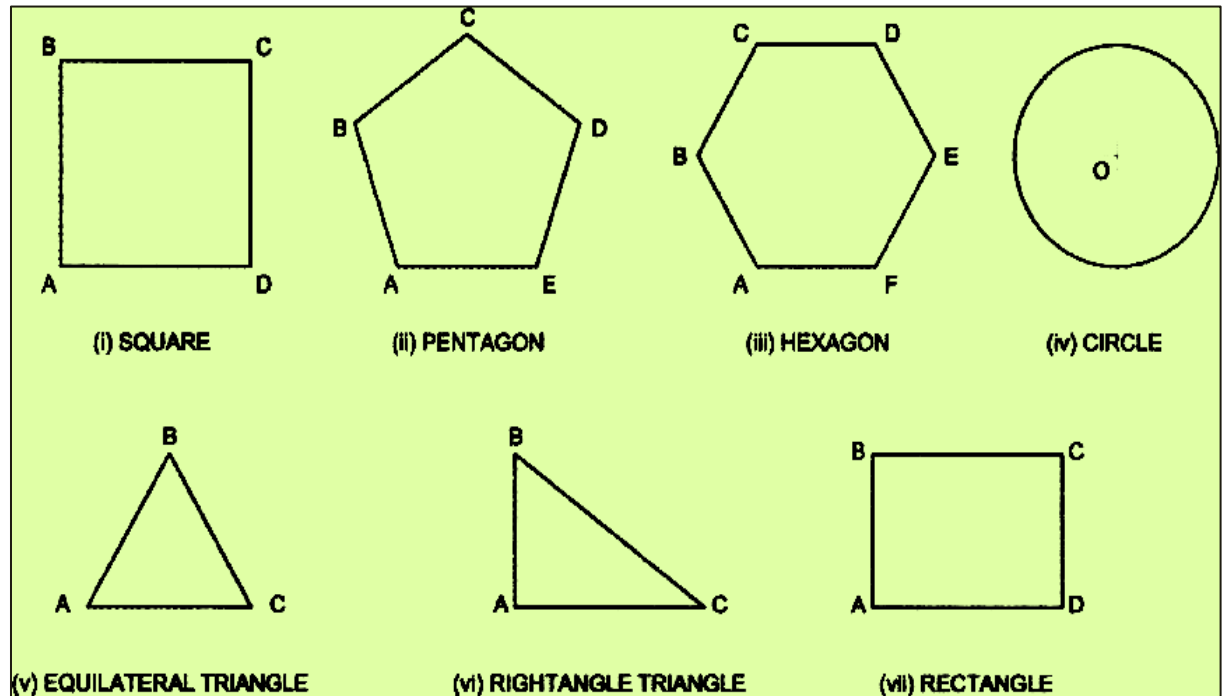


Fig 5.18

5.4.2 TYPES OF PLANES :

1. Perpendicular planes which have their surface perpendicular to any one of the reference planes and parallel or inclined to the other reference plane.
2. Oblique planes which have their surface inclined to both the reference planes.

5.4.3 TRACE OF PLANE :

The trace of a plane is the line of intersection or meeting of the plane surface with the reference plane; if necessary the plane surface is extended to intersect the reference plane. The intersection line of the plane surface with **HP** is called the **Horizontal Trace (HT)** and that of **VP** is called the **Vertical Trace (VT)**.

A plane figure is positioned with reference to the reference planes by referring its surface in the following possible position.

5.4.4 PROBLEMS :

Q. No. 1 : A Square plane with a 40mm side has its surface parallel to and 20mm above the HP. Draw its Projections, when (a) A side is parallel to VP (b) A side is inclined at 30° to VP

Solution :

Visualized position of surface plane Picture:

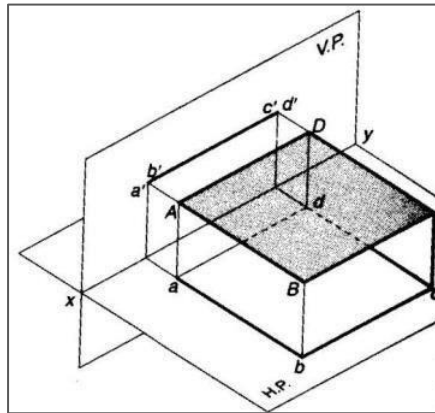


Fig 5.19

- Draw a square abcd of side 40mm such that one of its sides say ad is parallel to XY.
- Draw projectors from the points a & d.
- Locate the points a'b' at 20mm above XY.
- Draw a line through a' and parallel to XY intercepting the projector through d at c'd'. a'b'c'd' & abcd are the required projections.
- Similarly draw the projection of the point abcd when two of it's sides are inclined at 30° to VP.

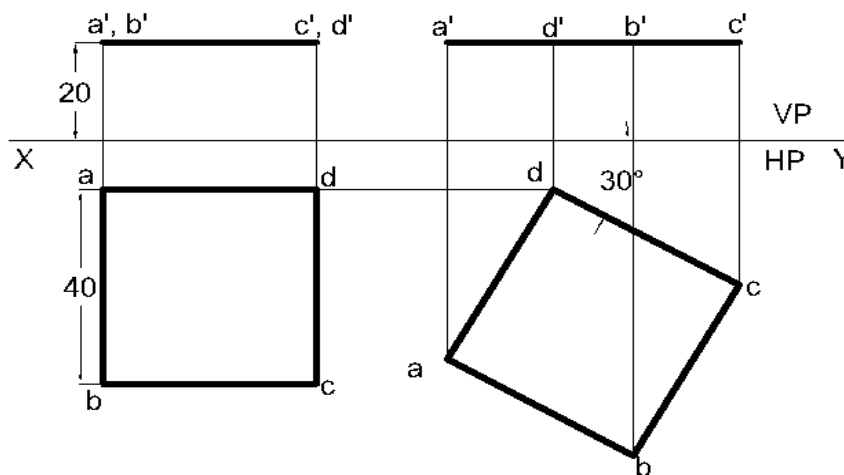


Fig 5.20 All dimensions are in mm

Q. No. 2. A Hexagonal plane with a 30mm side has an edge on the HP, the surface of the Plane is inclined at 45° to the HP. Draw it's Projections.

Solution : Visualized position of surface plane Picture:

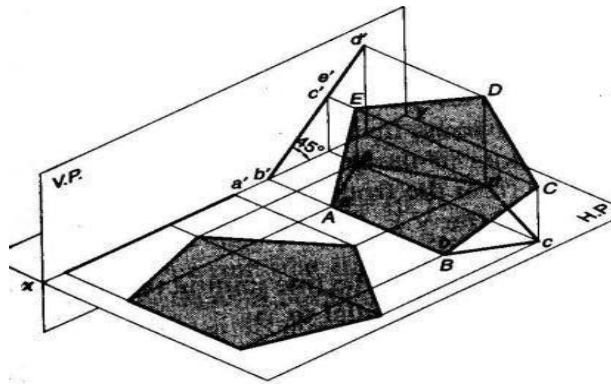


Fig 5.21

- Draw the reference axis XY and then draw the regular hexagon $a'b'c'd'e'f'$ in elevation such that one of its side $a'b'$ is perpendicular to the reference axis.
- Draw the top view $abcdef$ below XY and parallel to it.
- Draw the plan in changed position $a_1(b_1) f_1(c_1) e_1(d_1)$ so that it makes 45° with XY line and has the point a_1 15mm away from XY.
- Complete the corresponding new elevation $a_1'b_1'c_1'd_1'e_1'f_1'$ by projecting from this plane and projecting horizontally from the previous elevation.

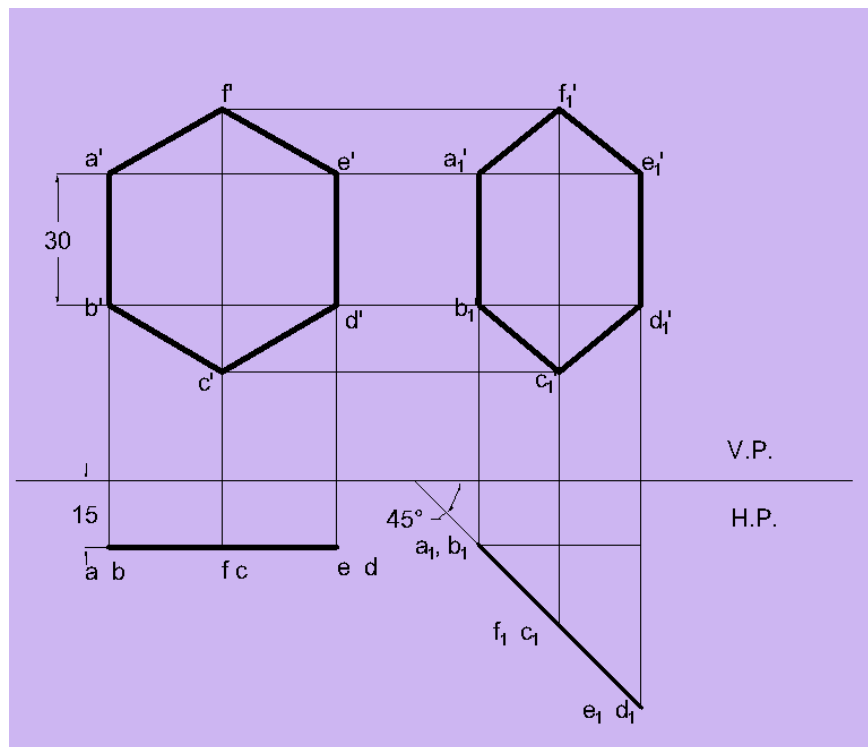


Fig 5.22

All dimensions are in mm

Q. No. 3. A Circular plane with a 60mm Diameter is resting on a point it's circumference on the VP. The center is 50 mm above the HP , and The surface is inclined at 45° to the VP. And perpendicular to the HP Draw It's Projections.

Solution :

- Draw the projection of the circle assuming it to be lying on VP and it's centre is 50mm above HP.
- Divide the circumference of the circle into 12 equal parts and name them as shown and transfer the division points on the top view.
- Redraw the Top view such that it makes an angle of 45° with XY and one end of it lies on XY forming the final Top view.
- Obtain the final front view by projection.

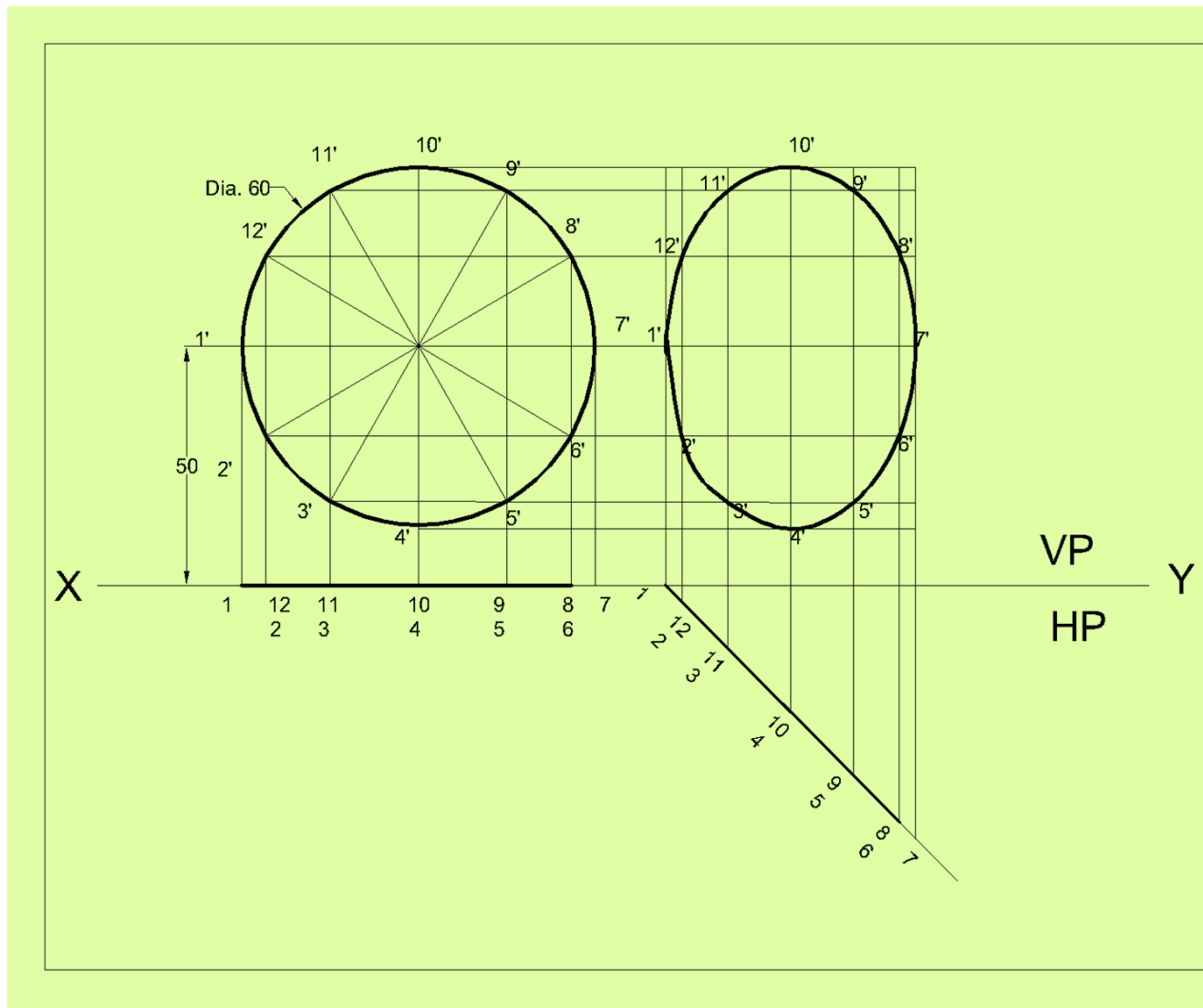


Fig 5.23

All dimensions are in mm

Q. No. 4. A regular pentagon ABCDE, of side 25 mm side has its side BC on ground. Its plane is perpendicular to H.P and inclined at 45° to the V.P. Draw the projections of the pentagon and show its traces when its corner nearest to VP is 15 mm from it.

Solution :

- As the plane makes an angle 45° to VP , so let's assume that the plane parallel to VP with one of its side say $d'e'$ on HP.
- The true shape of pentagon having side 25mm will be seen in the front view with one side on HP. $a'b'c'd'e'$ the required pentagon.
- The top view of the pentagon will be a line. Project the points. Draw the line eb at a distance 15mm from XY below it.
- Shift the top view eb to e_1b_1 of equal length making at an angle of 45° to VP as shown.
- Project the final front view $a_1'b_1'c_1'd_1'e_1'$ as shown.

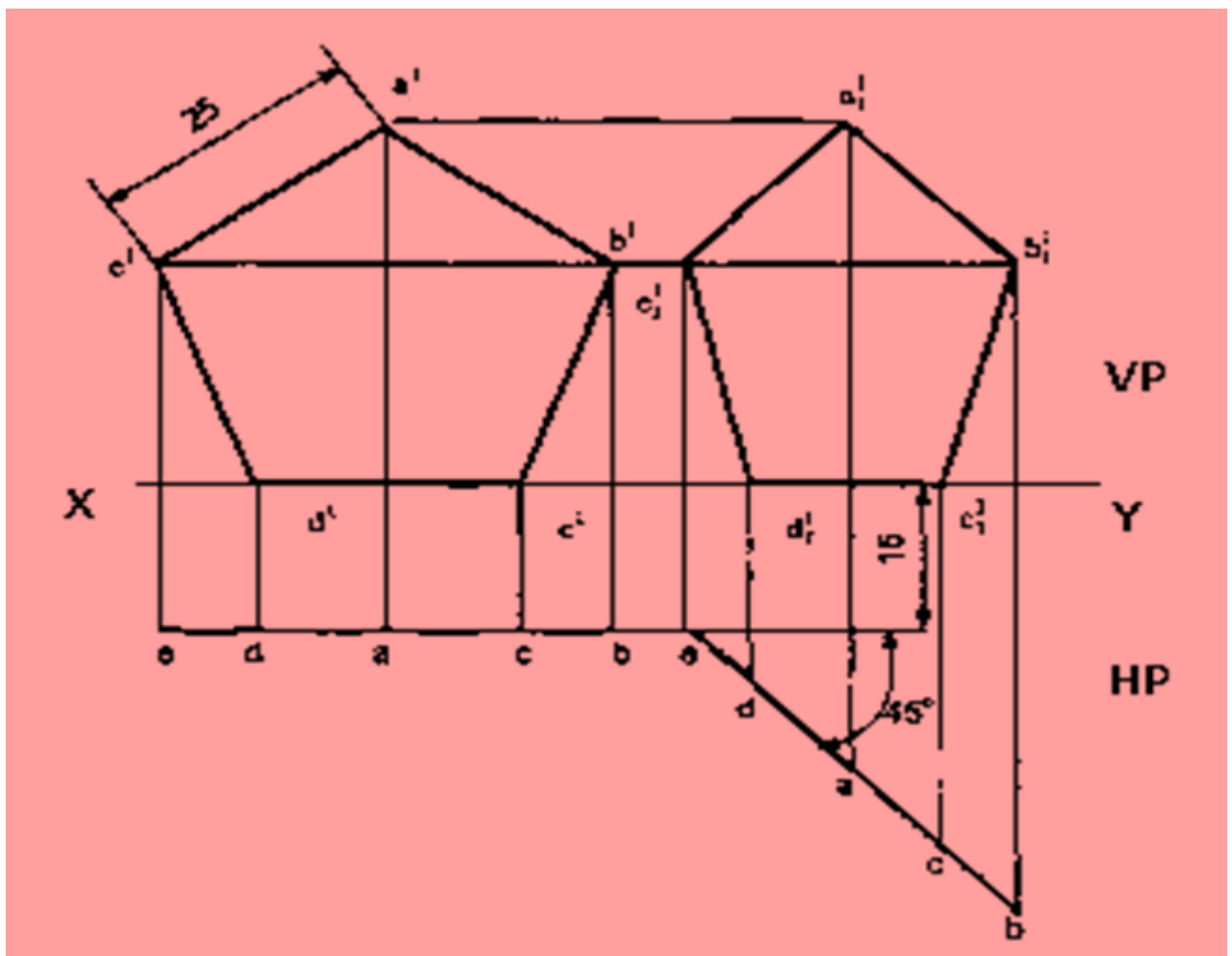


Fig 5.24

All dimensions are in mm

5.5 PROJECTION OF SOLIDS

5.5.1 INTRODUCTION :

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

- i. Polyhedral
- ii. Solids of revolution

Polyhedral

A polyhedral is defined as a solid bounded by plane surfaces called faces. They are:

- a. Regular polyhedral
- b. Prisms
- c. Pyramids

Regular Polyhedral

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

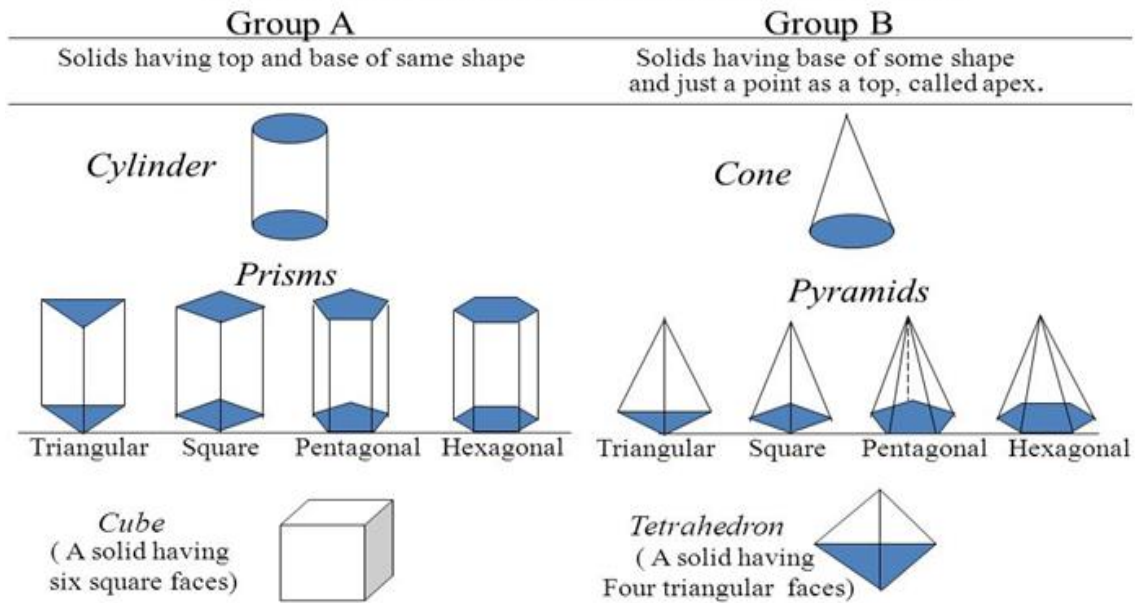
5.5.2 SOLIDS

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

A prism is named after the shape of its base. For example, a prism with square base is called a square prism, the one with a pentagonal base is called a pentagonal prism, and so on. The nomenclature of the prism is given in Fig 5.25.

SOLIDS

To understand and remember various solids in this subject properly, those are classified & arranged in to two major groups.



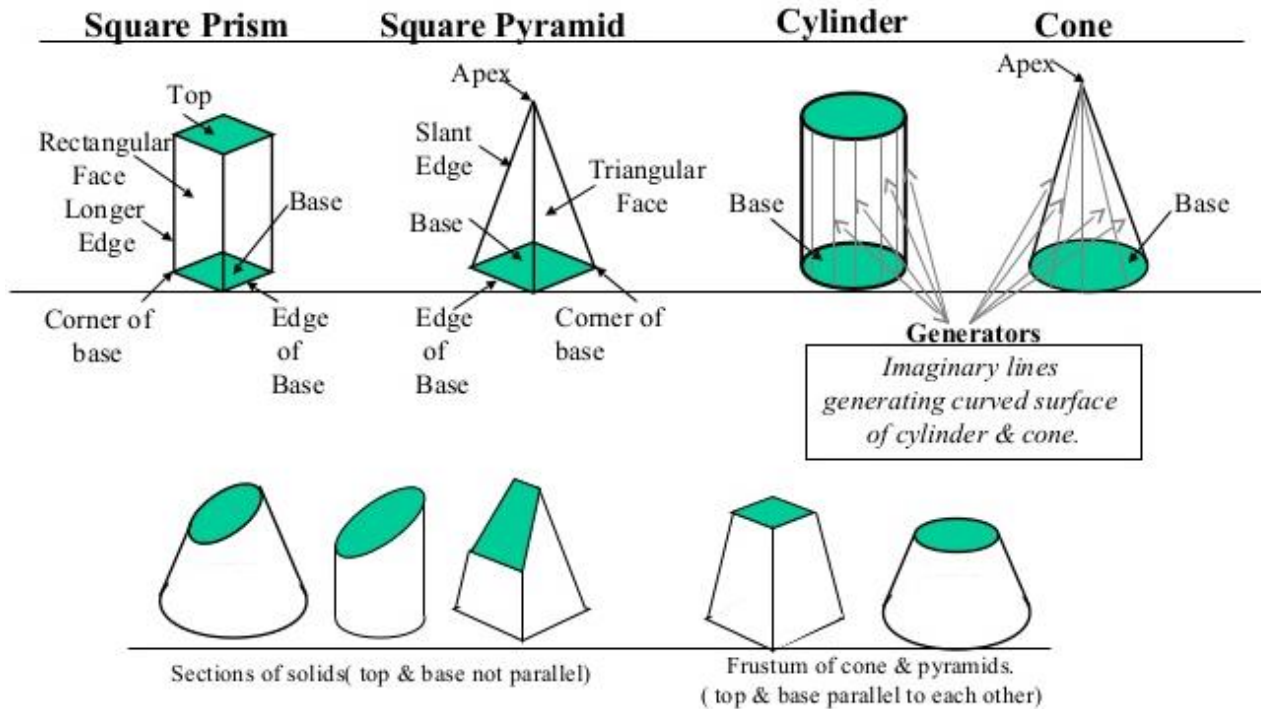
- a. **Tetrahedron:** It consists of four equal faces, each one being a equilateral triangle.
- b. **Hexahedron (cube):** It consists of six equal faces, each as square.
- c. **Octahedron:** It has eight equal faces, each an equilateral triangle.
- d. **Dodecahedron:** It has twelve regular and equal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

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

The pyramid is named after the shape of the base. Thus, a square pyramid has a square base and pentagonal pyramid has pentagonal base and so on. The nomenclature of a pyramid is shown in Fig 5.26.

SOLIDS

Dimensional parameters of different solids.



Types of Pyramids :

There are many types of Pyramids, and they are named after the shape of their base. These are Triangular Pyramid, Square Pyramid, Pentagonal pyramid, hexagonal pyramid and tetrahedron.

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

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

5.5.3 PROBLEMS

Q. No 1. Draw the projections of a cube of 35mm side, resting on one of its faces (bases) on HP., such that one of its vertical faces is parallel to and 10mm in front of VP.

Solution :

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

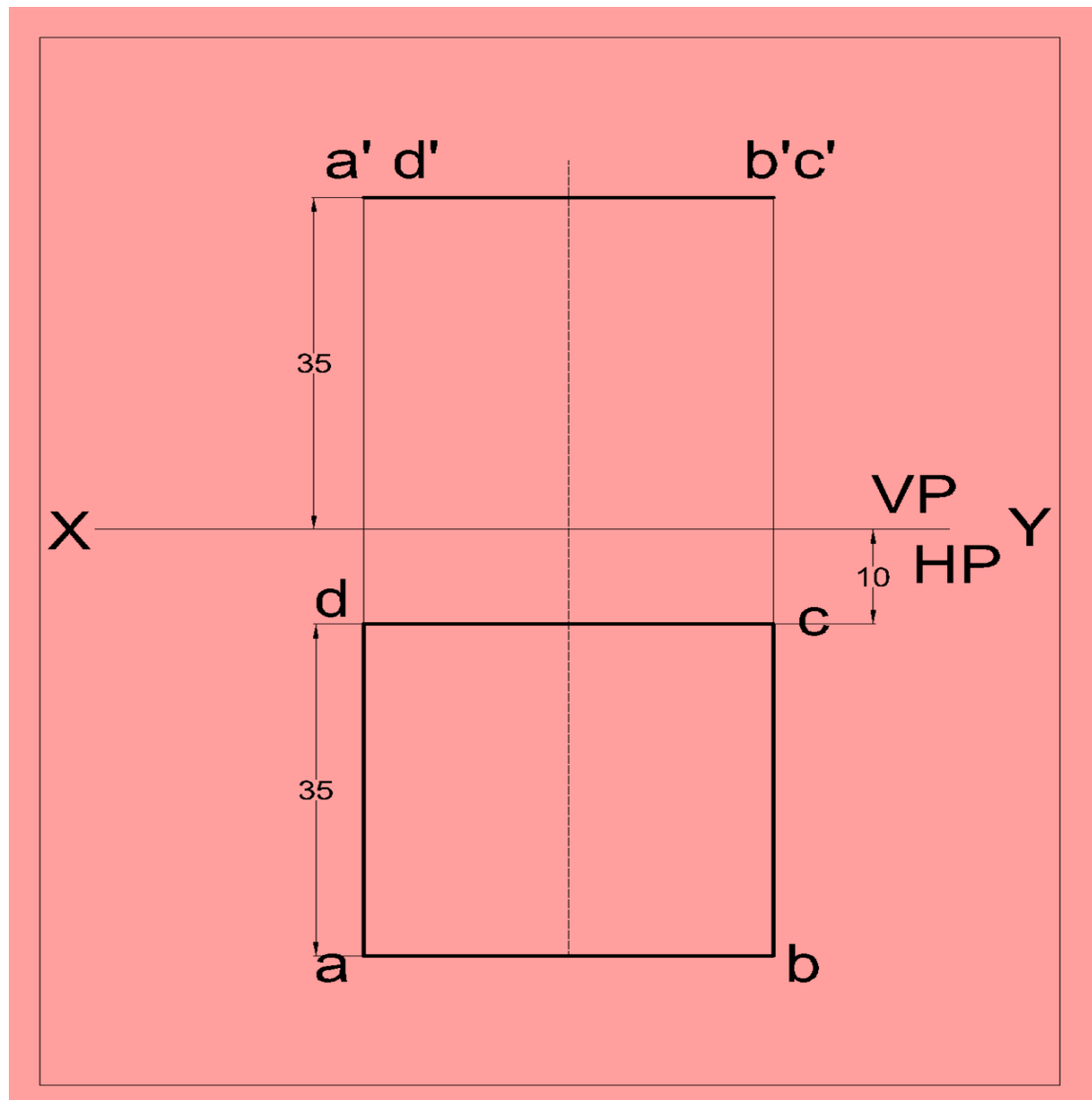


Fig 5.27

All dimensions are in mm

Q. No. 2. A triangular prism with side of base 35mm and axis 50mm long is resting on its base on HP. Draw the projections of the prism when one of its rectangular faces is perpendicular to VP and the nearest edge parallel to VP is 10mm from it.

Solution :

Draw the top view keeping one edge perpendicular to XY and one corner at 10mm from XY. Obtain the front view by projection, keeping the height equal to 50mm.

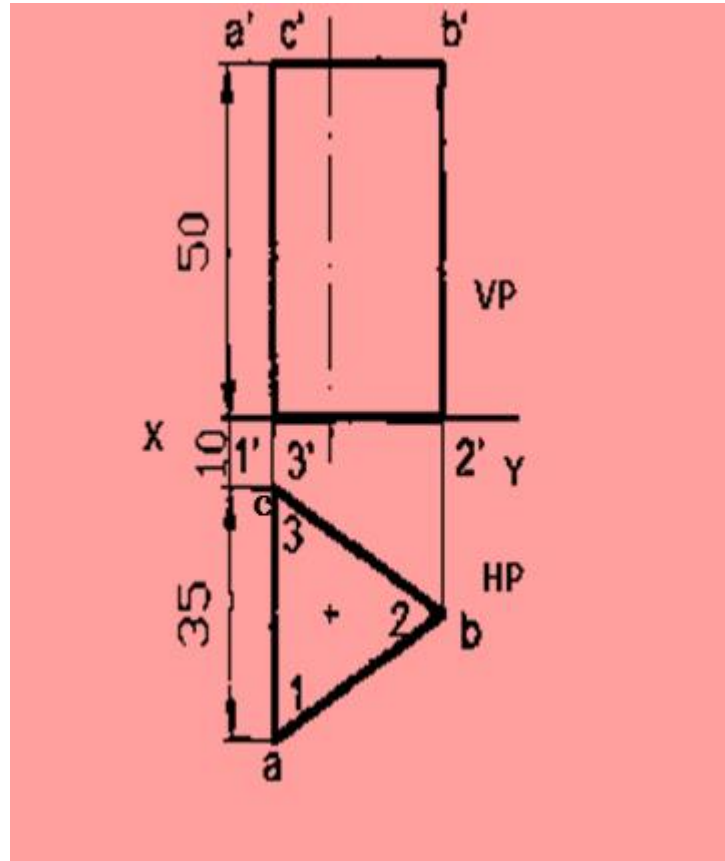


Fig 5.28

All dimensions are in mm

Q. No. 3. A pentagonal prism with side of base 30mm and axis 60mm long is resting on its base on HP such that one of its rectangular faces is parallel to VP and 15mm away from it. Draw the projections of the prism.

1. Draw the top view keeping one edge of the base parallel to XY and 15mm away from it.
2. Obtain the front view by projection keeping the height equal to 60mm.

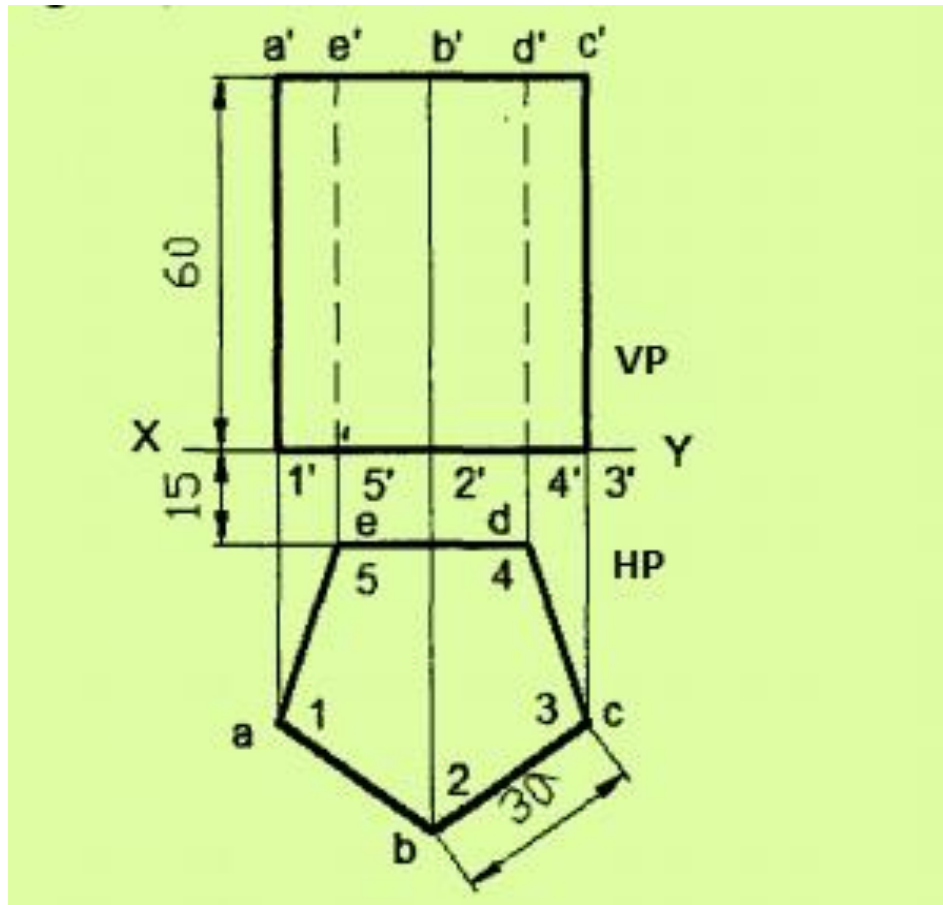


Fig 5.29

All dimensions are in mm

Q. No. 4.

A cylinder of base 60mm diameter and axis 100 mm long is resting on its base on the HP. The axis of the cylinder is 40mm in front of V.P. Draw the projections of the cylinder.

Solution :

- As the axis of the cylinder perpendicular to H.P, the top view must drawn first and then the front view will be projected from it.
- Draw a circle of diameter 60mm, representing the top view of the cylinder from a distance of 40mm from the XY.
- From top view project the front view which is a rectangle of height 100mm, its base coincide with XY as shown.

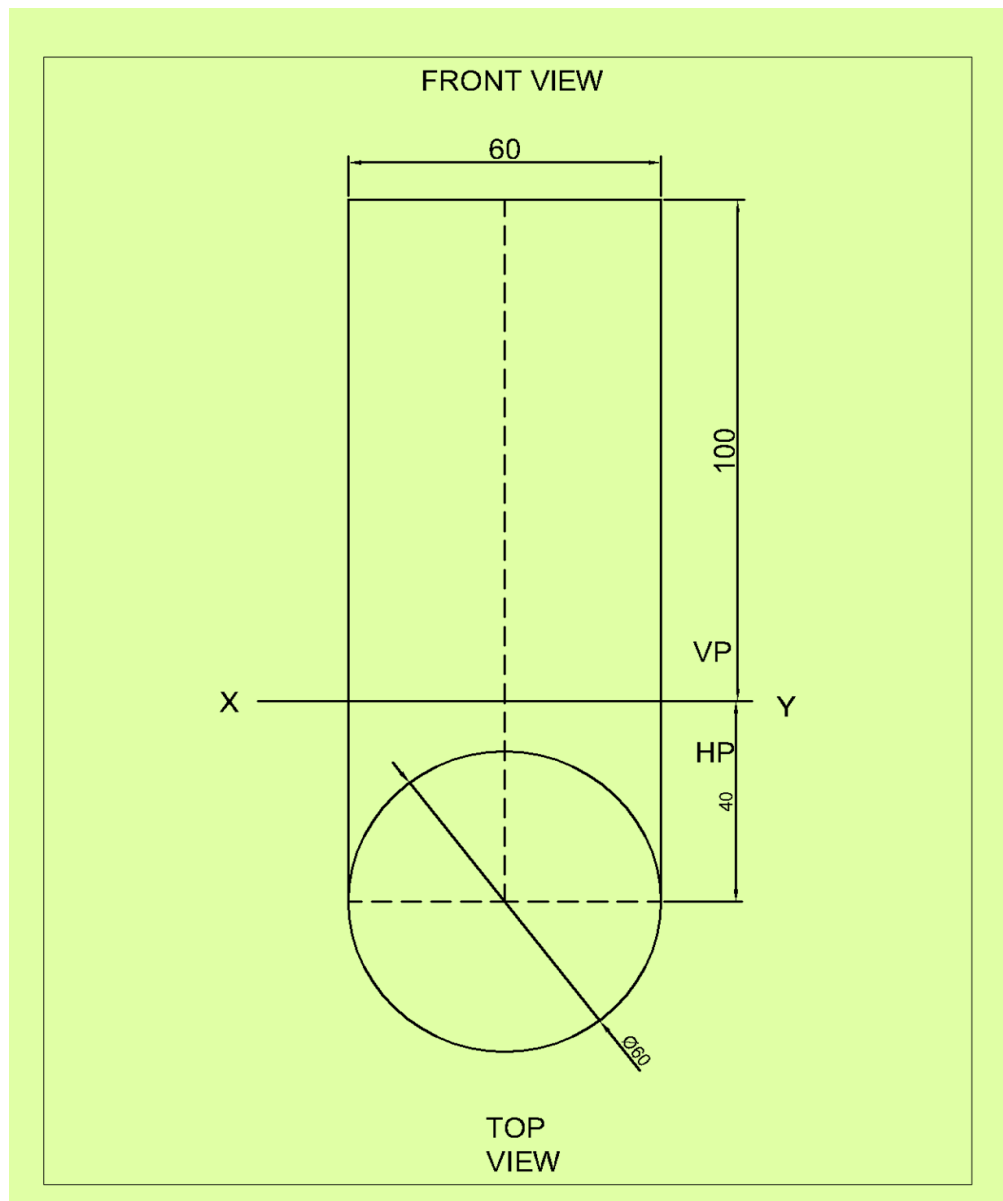


Fig 5.30

All dimensions are in mm

Q. No. 5. Draw the projection of the right circular cone of base 80mm diameter and height 90mm resting with its base on H.P. and 50mm in front of V.P.

Solution :

- The top view gives the true size of the base, so the top view is draw first.
- Draw the circle of about 80mm dia in a such a way that its axis is 50 below XY.
- Project the front view from top view as shown.

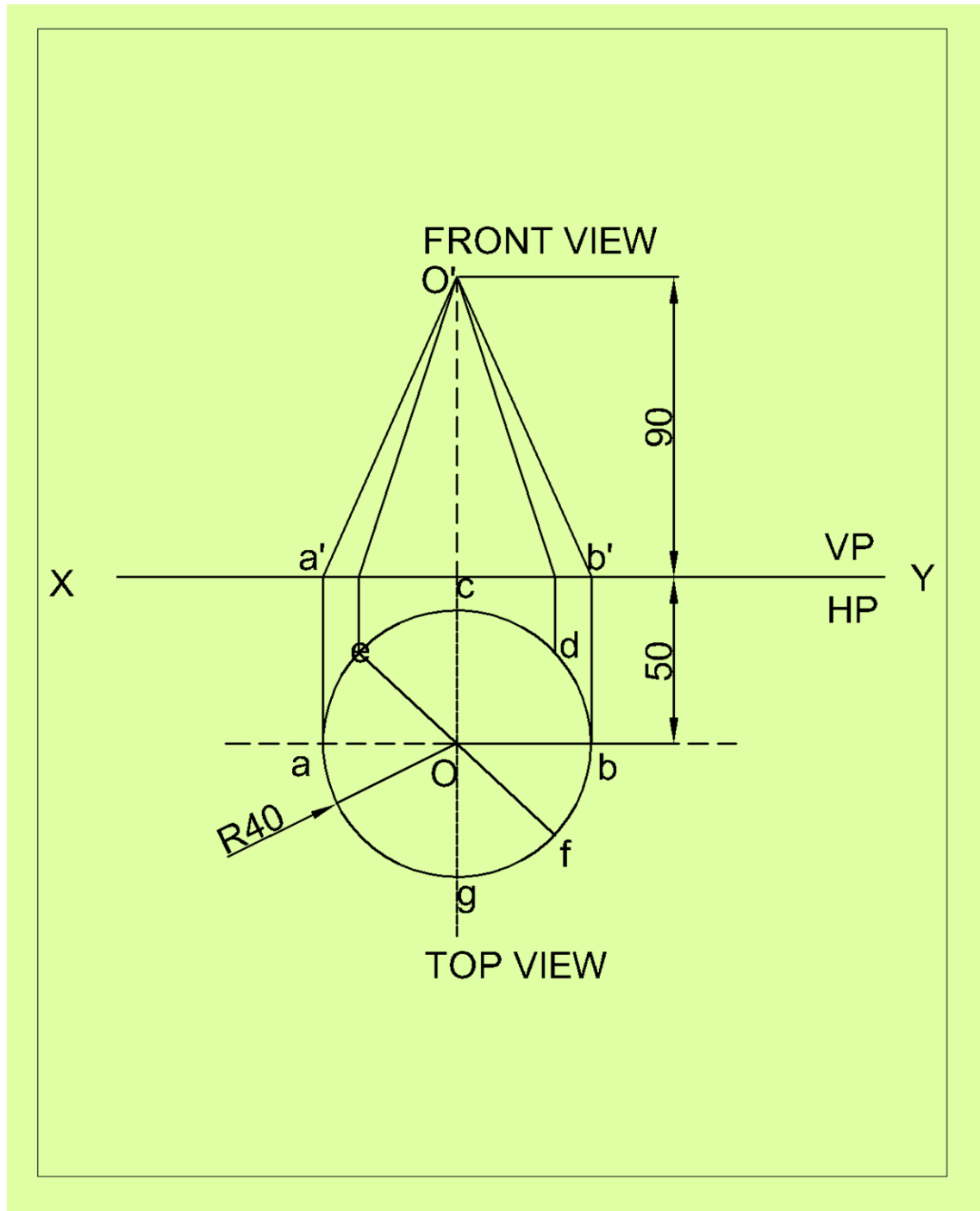


Fig 5.31

Q. No. 6.

Draw the projection of a right regular pentagonal pyramid of 30mm base and axis 70mm long is 50mm in front of V.P. The pyramid is resting on the H.P with one edge of the base perpendicular to the V.P.

Solution :

- As the pyramid is resting with base on H.P having axis perpendicular to the H.P, draw the top view of the pyramid keeping the axis 50mm in front of V.P. and edge perpendicular to the V.P.
- Draw the pentagon 12345 of side 30mm.
- Project the front view having height of the axis 70mm as shown.

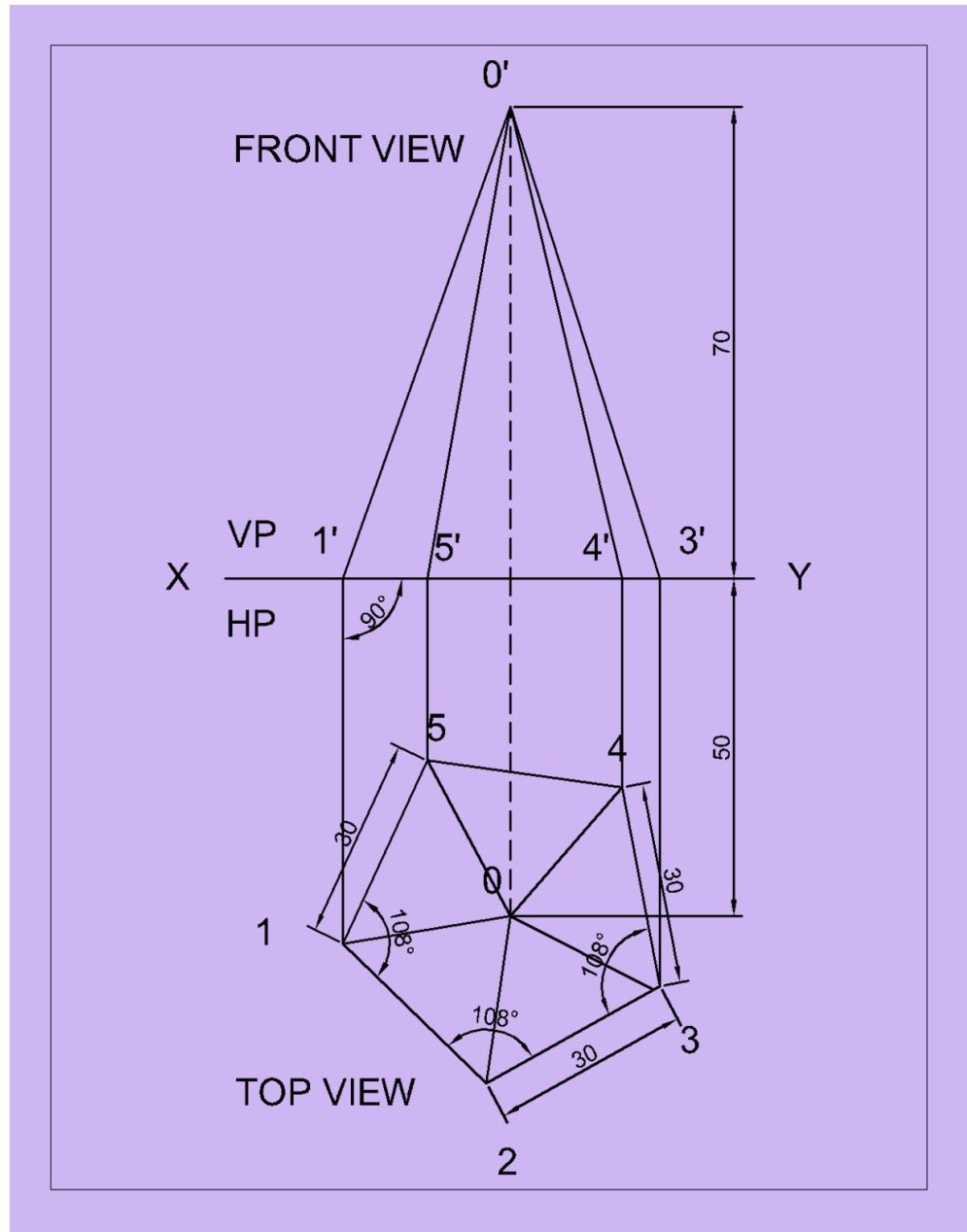


Fig 5.32

EXERCISES

1. A line PS 65mm has its end P 15mm above the HP and 15mm in front of the VP. It is inclined at 55° to the HP and 35° to the VP. Draw its projections.
2. A line CD, inclined at 25° to the HP, measures 80mm in top view. The end C is in the first quadrant and 25mm and 15mm from the HP and the VP respectively. The end D is at equal distance from the both the reference planes. Draw the projections, find true length and true inclination with the VP.
3. A straight line ST has its end S, 10mm in front of the VP and nearer to it. The mid-point M line is 50mm in front of the VP and 40mm above HP. The front and top view measure 90mm and 120mm respectively. Draw the projection of the line. Also find its true length and true inclinations with the HP and VP.
4. A line PQ has its end P, 10mm above the HP and 20mm in front of the VP. The end Q is 85mm in front of the VP. The front view of the line measures 75mm. the distance between the end projectors is 50mm. Draw the projections of the line and find its true length and its true inclinations with the VP and HP.
5. The plan of straight line PQ 85 mm long measures 70 mm while its elevation measures 55 mm. Its end P is in the HP and 20 mm in front of VP. Draw its projections and find the angle of inclination of the line with HP & VP.
6. A regular hexagonal plate of side 45mm lies on H.P with one of its side perpendicular to V.P . The plate is lying 25mm in front of V.P and inclined 45° to H.P. Draw the projections of the plate .
7. A regular pentagonal lamina ABCDE of 25 mm side has one side on the HP. Its surface is inclined at 45° to the HP and perpendicular to VP. Draw its projections.
8. A pentagon of sides 30mm rests on the ground on one of its corners with the sides containing the corners being equally inclined to the ground. The side opposite to the corner on which it rests is inclined at 30° to the VP and is parallel to the HP. The surface of the pentagon makes 10° with the ground. Draw the top and front views of the pentagon.
9. A regular pentagon of 30mm side is resting on one of its edges on HP which is inclined at 45° to VP. Its surface is inclined at 30° to HP. Draw its projections.
10. Draw the projections of a regular hexagon of 25mm side, having one of its sides in the H.P. and inclined at 60° to the V.P., and its surface making an angle of 45° with H.P.
11. A thin circular plate of 40mm diameter having its plane vertical and inclined at 40° . Its center is 30mm above H.P. and 35mm in front of V.P. Draw the projections.
12. A cone of base diameter 40 mm and axis height 60 mm rests on the ground on a point of its base circle such that the axis of the cone is inclined at 40° to the HP and 30° to the VP. Draw its front and top views.

CHAPTER-6

SECTION & DEVELOPMENTS

6.1 SECTIONING & DEVELOPMENT OF SOLID :

- An object (solid) is cut by some imaginary cutting plane to understand internal details of that object. The action of cutting is called **sectioning** a solid & the plane of cutting is called **section plane**.
- The development of surface of an object means the unrolling and unfolding of all surfaces of the object on a plane. If the surface of a solid is laid out on a plain surface, the shape thus obtained is called the **development of that solid**.

6.1.1 SECTION PLANE PERPENDICULAR TO THE V.P. AND INCLINED TO THE H.P. :

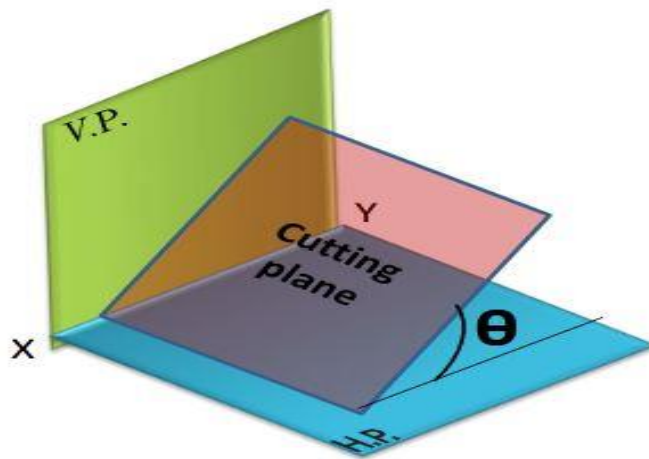
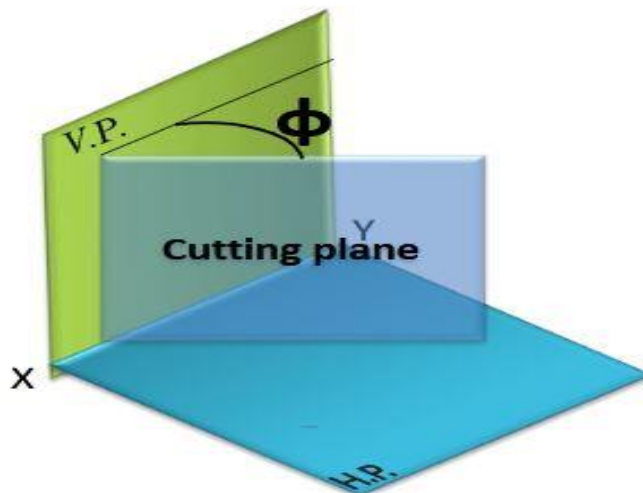


Fig 6.1

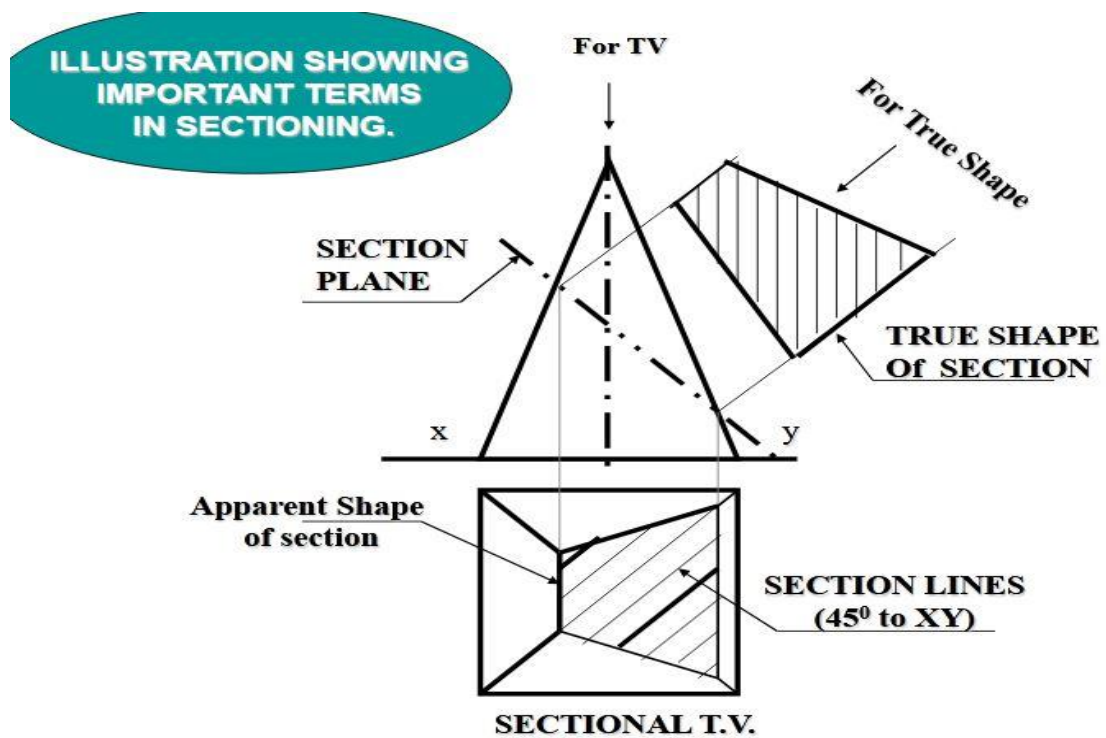
6.1.2 SECTION PLANE PERPENDICULAR TO THE H.P. AND INCLINED TO THE V.P. :



VP = VERTICAL PLANE

HP = HORIZONTAL PLANE

Fig 6.2



(TV=TOP VIEW, FV=FRONT VIEW)

Fig 6.3

Typical Section Planes & Typical Shapes Of Sections.

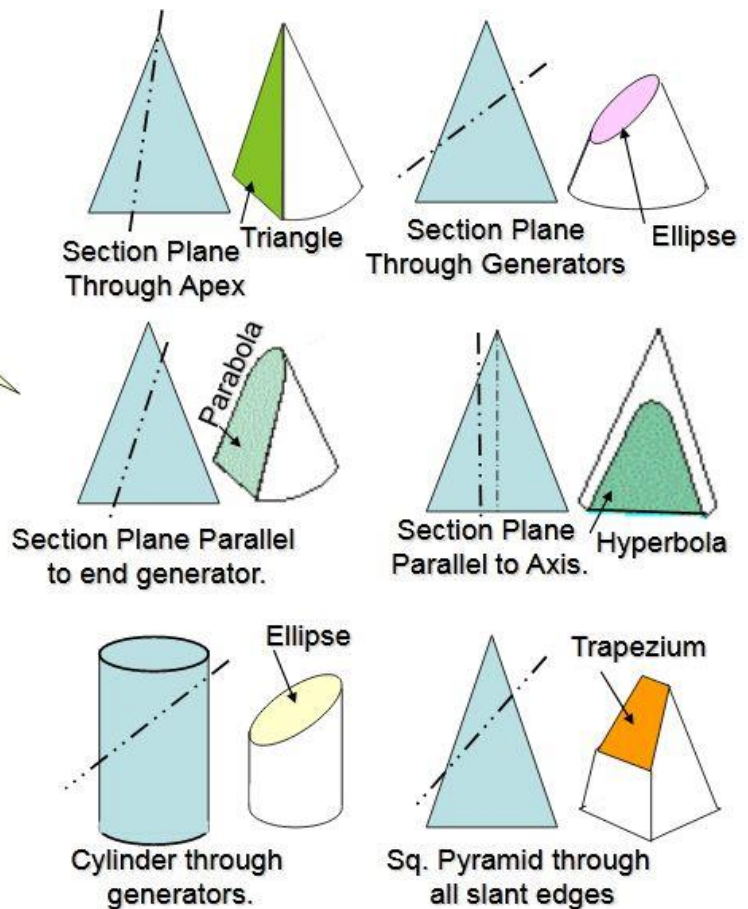


Fig 6.4

6.2 SHAPE OF THE CUTTING SECTIONS

6.2.1 SECTIONAL PROJECTION OF PRISM

SOLVED PROBLEMS

Q. No. 1. Draw the front view, sectional top view and true shape of the section of a hexagonal prism of side 40 mm and 80 mm high lying on HP with a nearest side parallel to VP and 30 mm in front of it. It is cut by a plane perpendicular to VP and inclined to HP at an angle 45° passing through a point on the axis 50 mm above the base.

Solution :

- Draw the top view and front view of the hexagonal prism of base 40mm and axis 80mm.
- Mark the point on the axis 50mm above the base and draw a cutting plane line through this point inclined at an angle 45° to HP.
- Mark the numbering and point of intersection in front view and top view and transfer these points in the section plan and draw section lines in the cut portion in the top view.
- Project the projection at right angle to the cutting plane line from the interacting points and complete the true shape. Take distances equal to the corresponding distances on the plan and join the point and complete the true shape by drawing section lines.

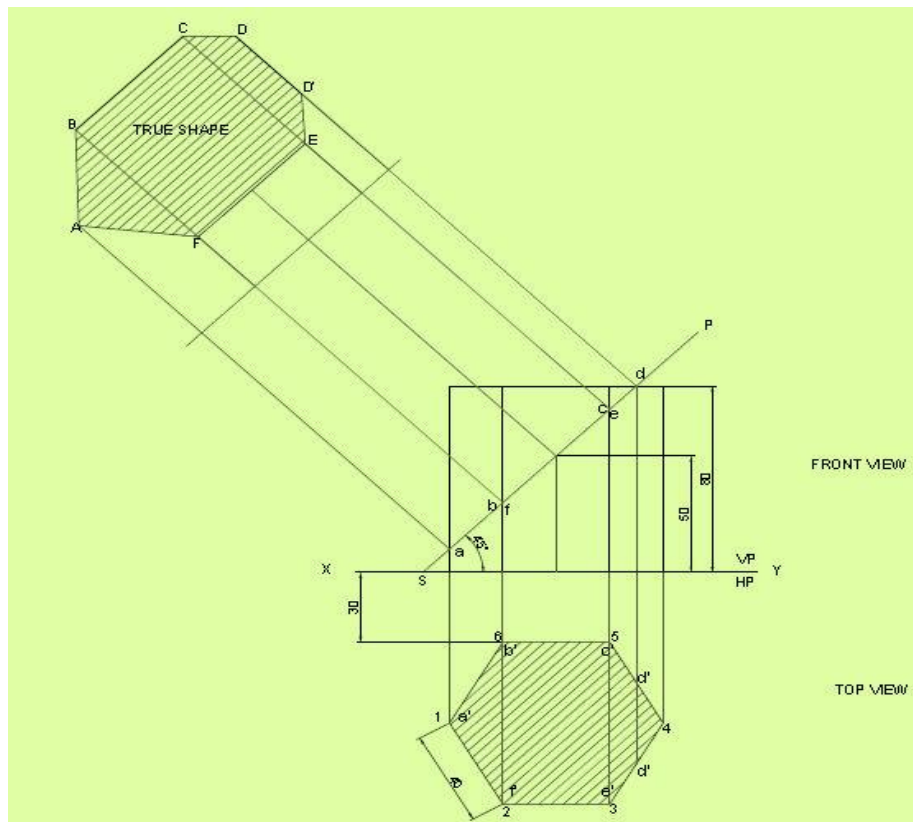


Fig 6.5

6.2.2 DEVELOPMENT OF PRISM

Q. No. 2. Draw the development of the lateral surface of the hexagonal cut prism of base 40 mm and axis 80 mm is resting on HP in such a way that a rectangular face is parallel to VP. The section plane is perpendicular to VP and inclined at 30° to HP and passing through the top end of an extreme lateral edge of the prism.

Solution :

1. Draw the top and front view of prism from given data.
2. Draw the full stretched portion of length 240 mm. (6 x 40 mm).
3. Draw the section plane as per condition provided and do the proper nomenclature.
4. Project the points from front view to the full stretched portion and draw the development of the section.

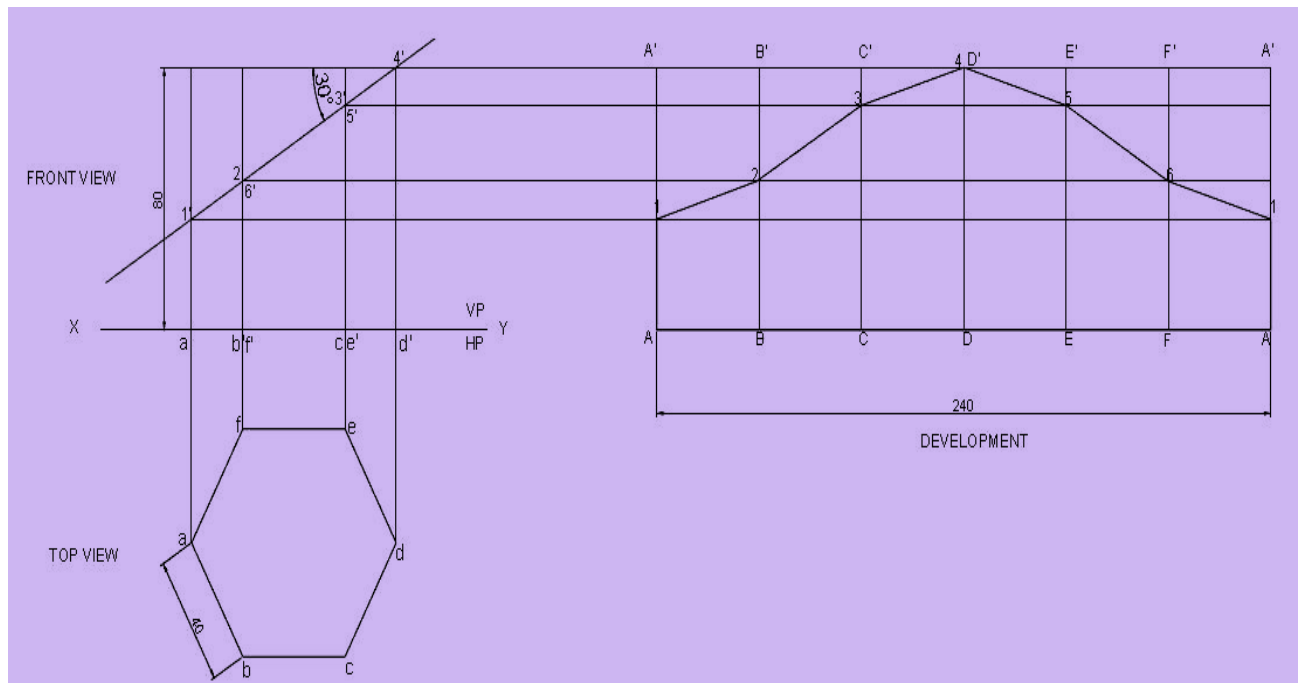


Fig 6.6

6.2.3 SECTIONAL PROJECTION OF CYLINDER

Q. No. 3. A cylinder 80 mm diameter and 90 mm long is resting on its base on ground. It is cut by a section perpendicular to VP. The VP of which cuts the axis at a point 45 mm from the base and makes an angle 45° to HP. Draw the sectional front view, sectional top view and true shape of the section.

Solution :

1. Draw the top view and front view of the cylinder with 80 mm diameter and 90 mm long.
2. Draw a section plane in such a way that it cuts the axis of the cylinder in front view at a distance 45 mm base and makes 45° to HP.
3. Draw the projection for sectional top view and true sectional view as shown below.

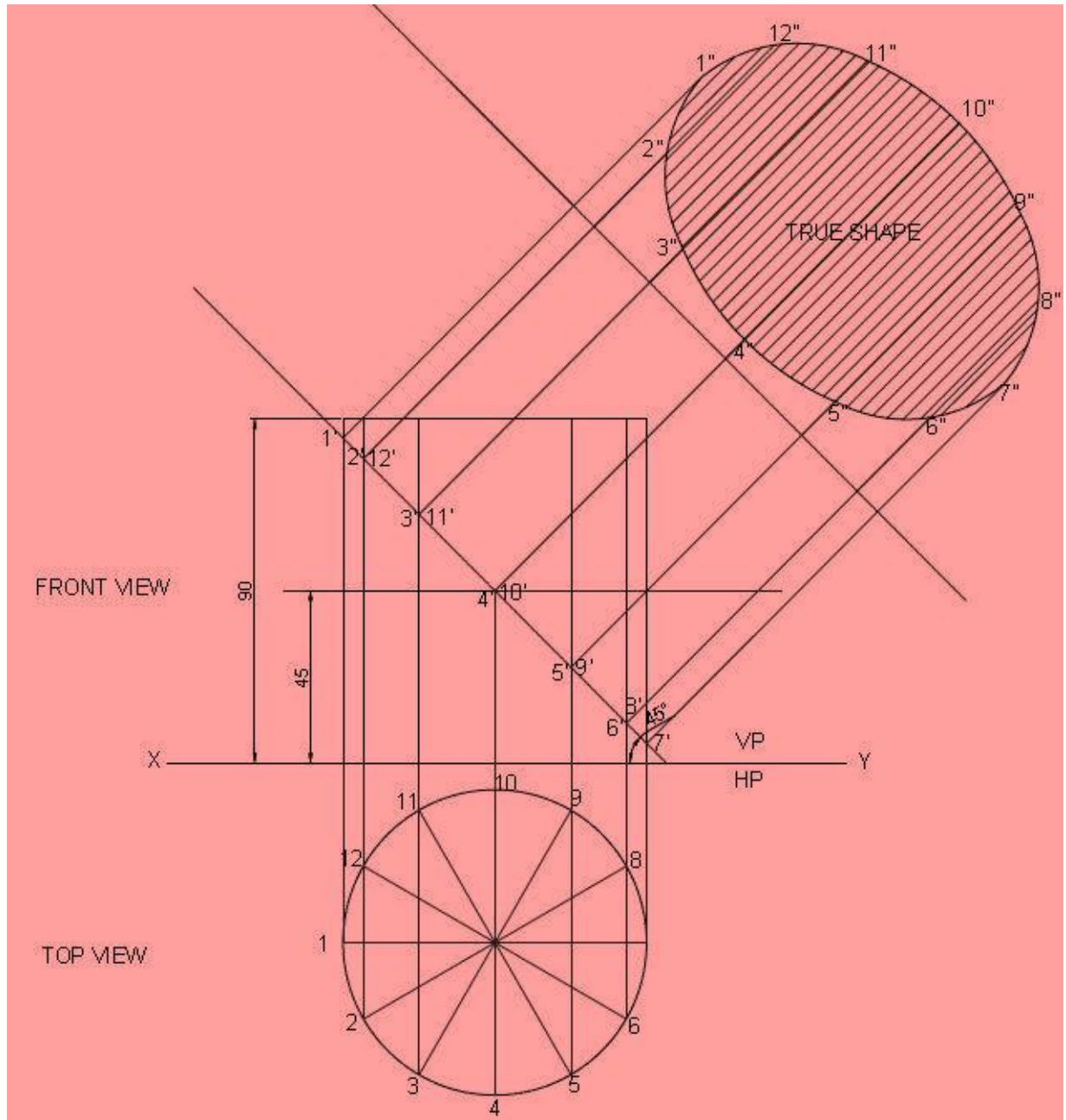


Fig 6.7

6.2.4 DEVELOPMENT OF CYLINDER

Q. No. 4. A right cylinder of 50mm diameter and 65 mm height is resting on its base on HP. It is cut by a section plane perpendicular to VP and inclined at 45° to HP in such a way that it passes through the top end of an extreme generator of the cylinder. Draw the development of the truncated cylinder.

Solution :

- Draw the top view and front view of the cylinder.
- Divide the circumference into 12 equal parts and locate the corresponding generators in the front view.
- Draw the stretch out of the cylinder length and height.
- Now the front view is cut by a section plane as per the given condition in the question as shown.
- Divide the stretch out and project the lines from the front view and complete the development as shown.

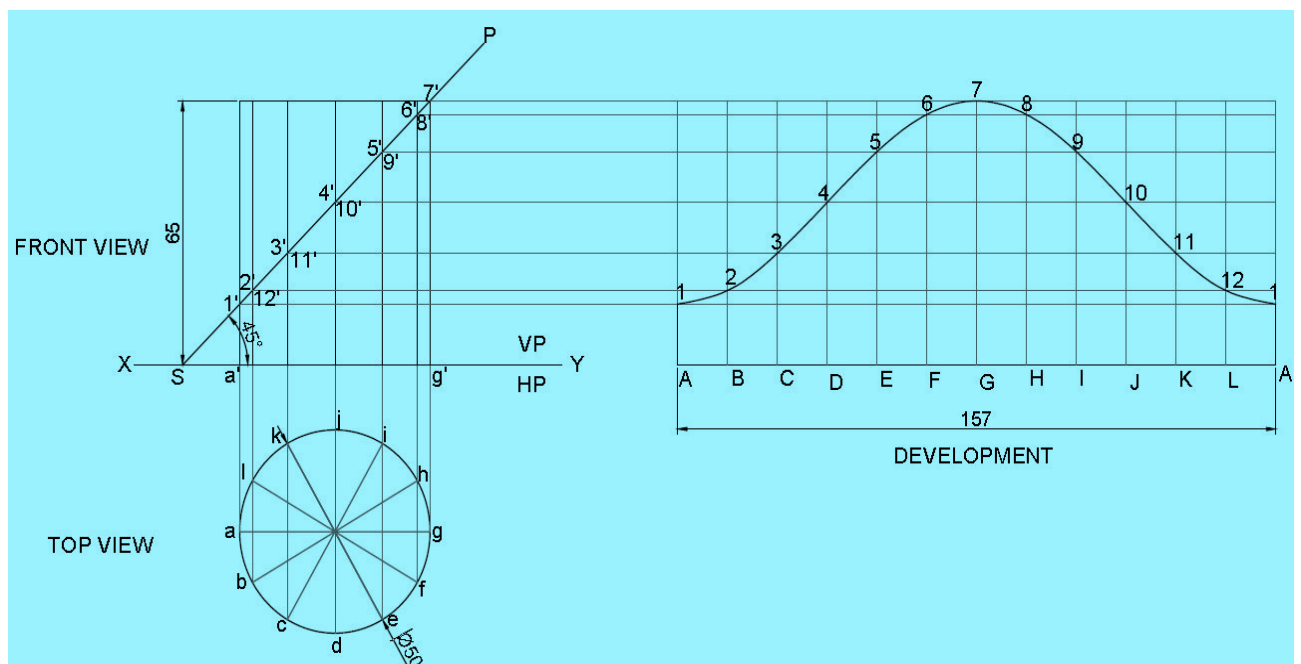


Fig 6.8

6.2.5 SECTIONAL PROJECTION OF CONE :

Q. No. 5. A right circular cone of base diameter 60 mm and axis 70 mm is resting on H.P. It is cut by section plane which makes an angle 60° to V.P. and passing through the point 15 mm from axis. Draw sectional front view, top view, and true shape of section.

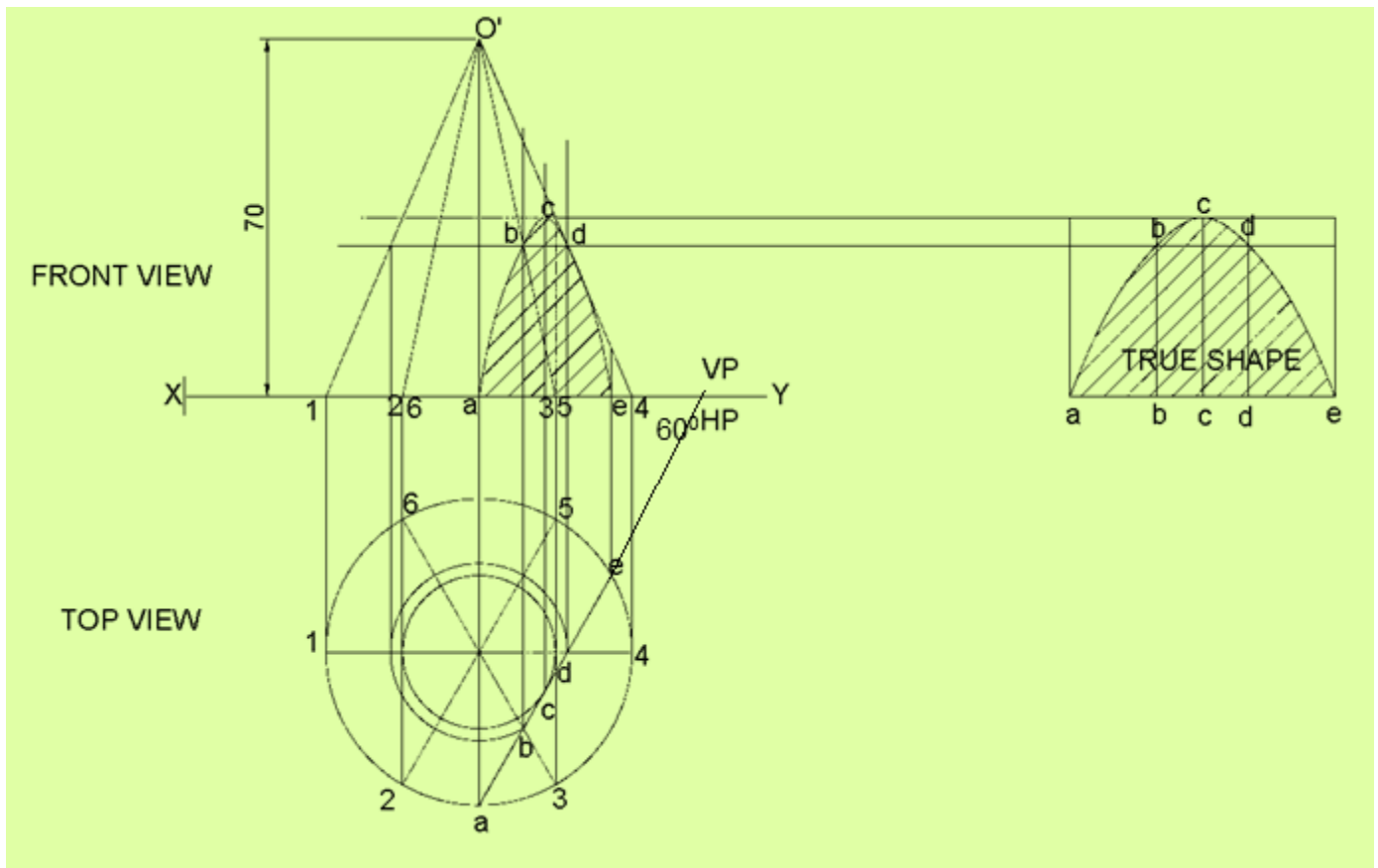


Fig 6.9

6.2.6 DEVELOPMENT OF CONE

Q. No. 6. A cone of base 60 mm dia. And height 70mm rests with its base on HP. A section plane perpendicular to VP and inclined at 30° to HP bisects the axis of the cone. Draw the development of the lateral surface of the truncated cone.

Solution :

- Draw the front view and top view of the cone of dia 60mm and height 70mm.
- Now divide the top view i.e a circle into 12 equal no. of parts and name it.
- Development of the cone is a sector of a circle of radius equal to the true length of slant height. The length of the arc is equal to the circumference of the base circle πD and the angle subtended at the centre (Θ).

$$\Theta = 360^\circ \times \frac{\text{Radius of base circle}}{\text{Slant height}}$$

$$\text{i.e. } \Theta = 360^\circ \times (r/l)$$

- Divide the arc in 12 parts and name accordingly.
- Draw the section plane at 30° to XY in such a way that bisecting the axis in front view.
- Project the cutting plane as shown and complete the development.

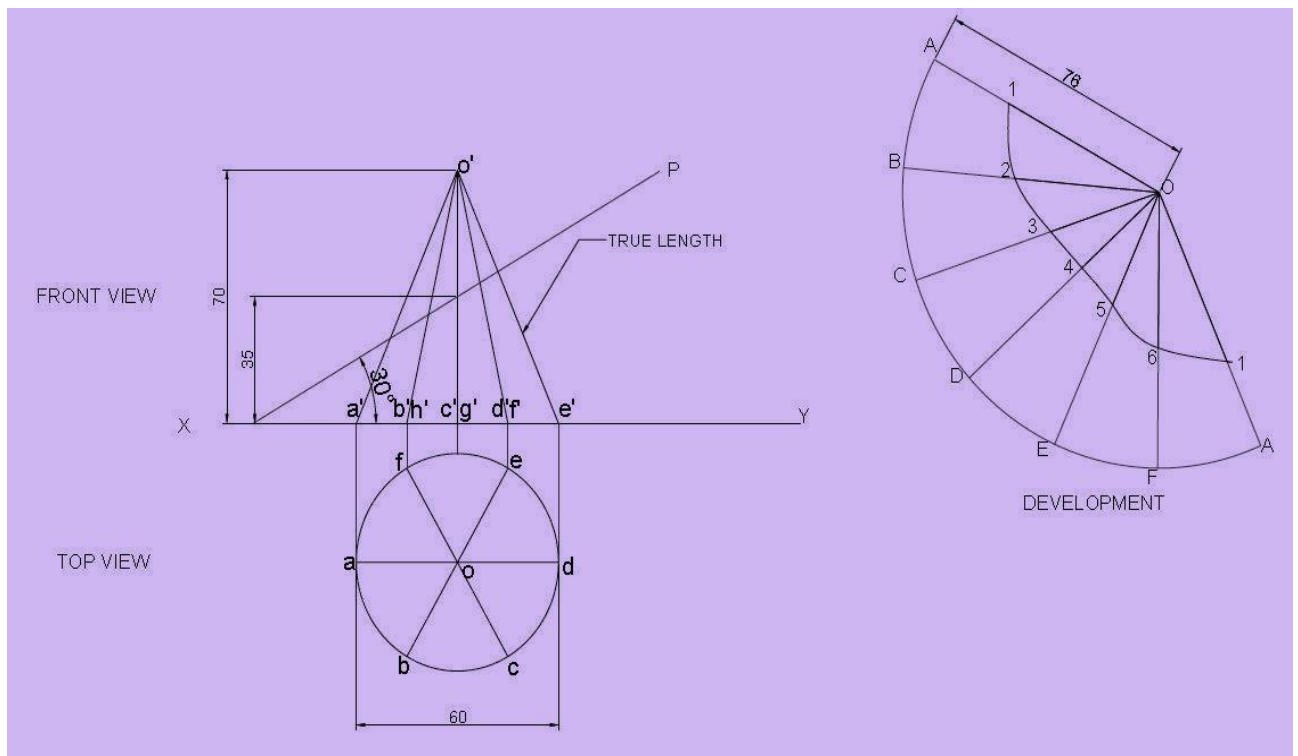


Fig 6.10

6.2.7 SECTIONAL PROJECTION OF PYRAMID

Q. No. 7. A hexagonal pyramid of side of base 40 mm and axis 75 mm long is resting on its base at HP with two edges parallel to the VP. It is cut by a section plane inclined at 45° to HP and passing through the axis at 30 mm from the base. Draw the projections of solid and show the true shape of the section.

Solution :

- Draw the top view and front view of hexagonal pyramid of base 40 mm and axis 75 mm long resting on its base on HP.
- Draw the section plane inclined at 45° to XY and passing through a point on the axis in such a way that it passes 30mm from the base.
- Locate the points of intersection between the section plane and edges of the pyramid.
- Project and locate these points on the corresponding edges in the top view. Join the points in the order by straight lines and complete the sectional top view.
- To obtain the true shape of the section draw the reference line X'Y' (auxiliary axis) parallel to the section plane.
- Project the points through X'Y' and obtain the true shape of the section as shown.

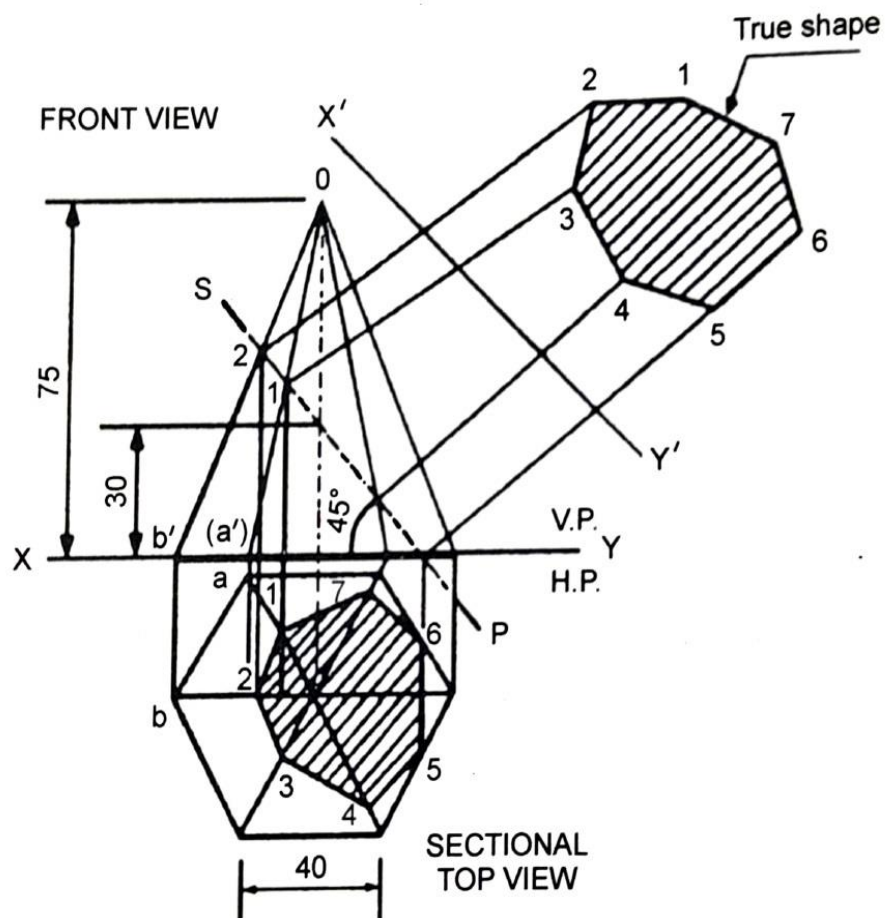


Fig 6.11

6.2.8 DEVELOPMENT OF PYRAMID :

Q. No. 8. A right regular pentagonal pyramid, edge of base 30 mm and height 60 mm is resting on its base in HP with axis parallel to VP. Two of its base edges are equally inclined to the VP. The pyramid is cut by a section plane at an angle of 45° to HP and 10 mm away from base on the edge of the corner. Draw the development of the surface.

Solution :

- Draw the top view and front view as per given condition.
- Draw a section plane inclined 45° to HP, leaving a vertical distance of 10mm from its base and name the parts.
- Draw the development of lateral surfaces.
- Draw an arc with radius equal to the true length of the edge in the front view.
- In the front view project the points on the true length and name the points and make the distance from the apex and transfer the distances on the development surface as shown.

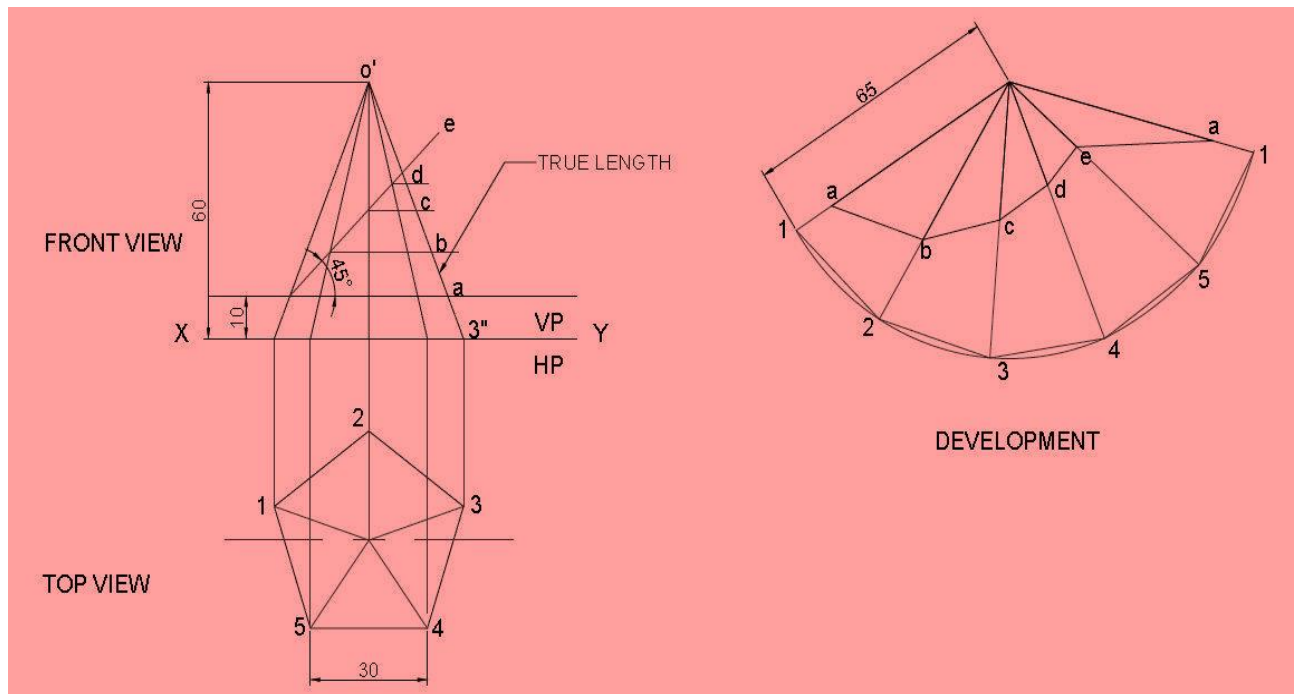


Fig 6.12

EXERCISES

1. A hexagonal prism of base of side 40 mm and axis length 80 mm rests on one of its base edges on the HP. The end containing that edge is inclined at 30° to the HP and the axis is parallel to VP. It is cut by a plane perpendicular to the VP and parallel to the HP. The cutting plane bisects the axis. Draw its front and the sectional top views.
2. A square pyramid of base side 30 mm and altitude 50 mm lies on one of its triangular faces on the HP with its axis parallel to the VP. It is cut by a vertical plane inclined at 30° to the VP and meeting the axis at 40 mm from the vertex measured in the plan. Draw the top view, sectional front view and the true shape of the section.
3. A Hexagonal pyramid of base side 30 mm and height 60 mm rests vertically on its base on the ground with two of its base sides parallel to VP. It is cut by a sectional plane inclined at 30° to HP and perpendicular to VP and meeting the axis at the midpoint. Draw the development of the lateral surfaces of a truncated pyramid.
4. Draw the development of the lateral surfaces of the hexagonal cut Prism of base 40mm axis 80 mm is resting on H.P in such a way that a rectangular face is parallel to V.P. The section plane is perpendicular to VP and inclined at 30° to H.P and passes through the top end of an extreme lateral edge of the prism.
5. A right regular pentagonal pyramid of base 40mm and axis 80 mm is resting with its base on H.P and one of the base of the edges of its base perpendicular to V.P. The section plane is parallel to H.P and passing through the axis at a point 50mm above the base. Draw the front view and sectional top view.
6. A right regular hexagonal pyramid, edge of base 30 mm and height 50 mm, rests on its base on ground plane with one of its base edge parallel to VP. A section plane parallel to HP cuts the pyramid bisecting its axis. Draw its front view and sectional top view.
7. A cylinder 60 mm in diameter and 70 mm long is resting on its base on ground. It is cut by a section plane perpendicular to VP and cuts the axis at a point 45 mm from the base making an angle of 40° to HP. Draw the sectional front view and true shape of the section.

CHAPTER – 7

ISOMETRIC PROJECTIONS

ISOMETRIC PROJECTION :

- Isometric projection is a method for visually representing three-dimensional objects in two dimensions.
- It is an axonometric projection in which the three coordinate axes appear equally foreshortened and the angle between any two of them is 120° .

CONSTRUCTION OF ISOMETRIC SCALE

METHOD 1 :

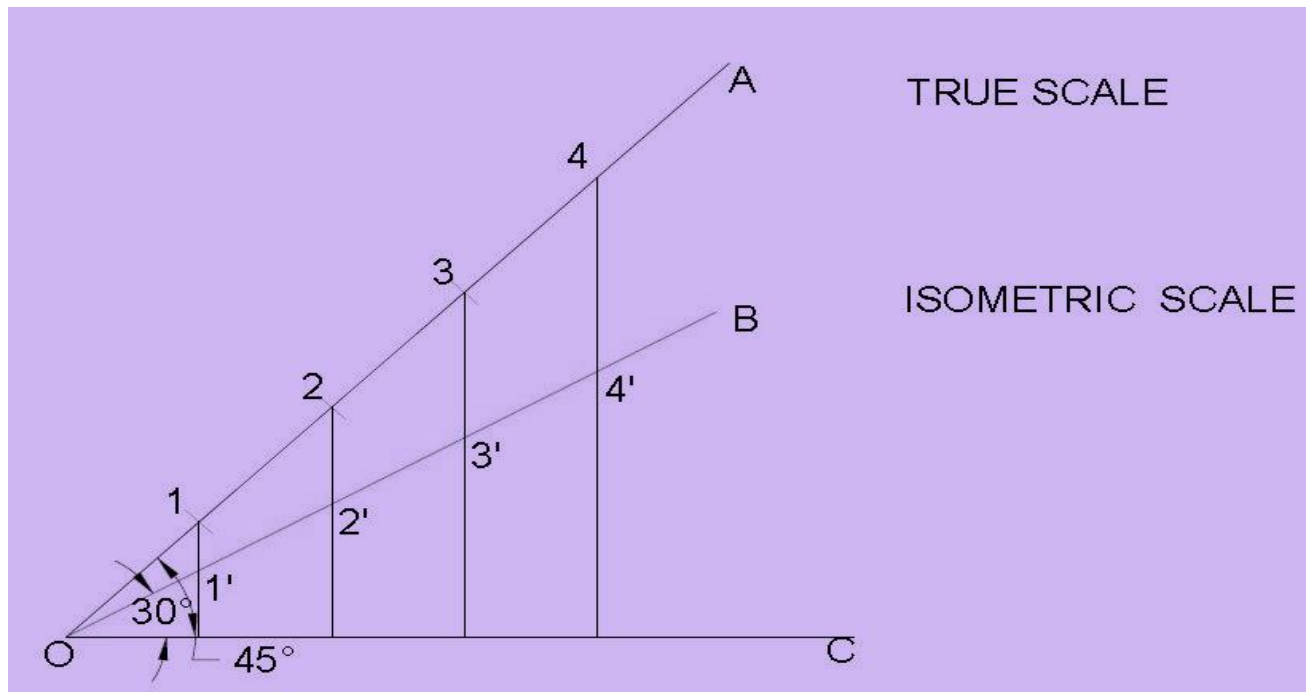


Fig 7.1 (a)

- Draw a horizontal base line OC.
- Draw OB & OA which make 30° and 45° with OM respectively.
- On line OA mark the division points as 1,2,3,4,5.... with each division as 10 mm.
- From each division points draw perpendicular to OC ,intersecting the line OB at 1',2',3',4' and so on.
- Mark the corresponding points on OB obtaining the isometric scale.

METHOD 2 :

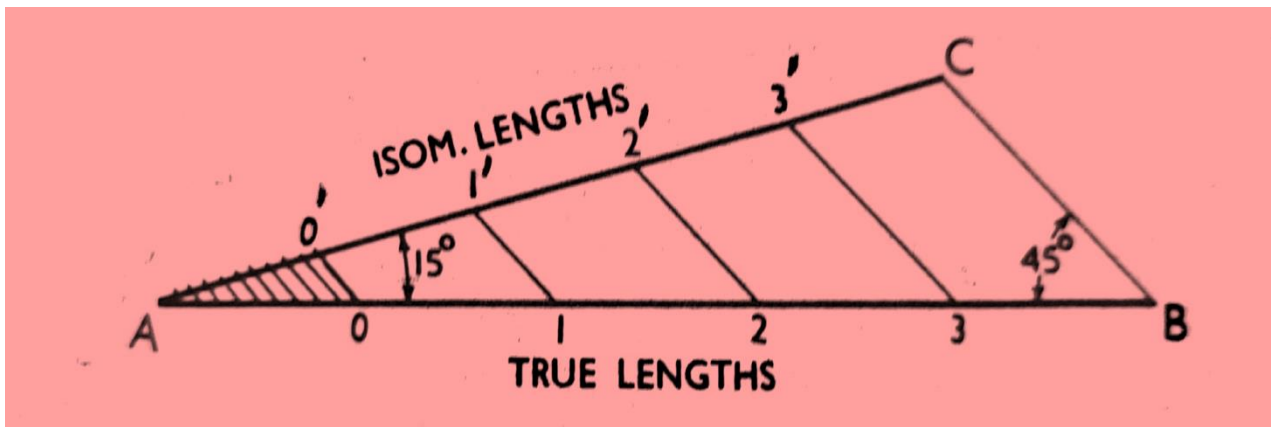


Fig 7.1(b)

- Draw a horizontal base line AB.
- Draw AC which make an angle 15° with base AB and draw BC which make an angle 45° with AB respectively.
- On line AB mark the division points as 0,1,2,3,... with each division as 10 mm.
- Draw parallel lines with BC from the points 0,1,2,3, .. , intersecting the line AC at 0',1',2',3' and so on.
- Measure the isometric lengths on the isometric scale on the line AC.

NOTE :

ISOMETRIC VIEW : It is drawn by using full/true scale.

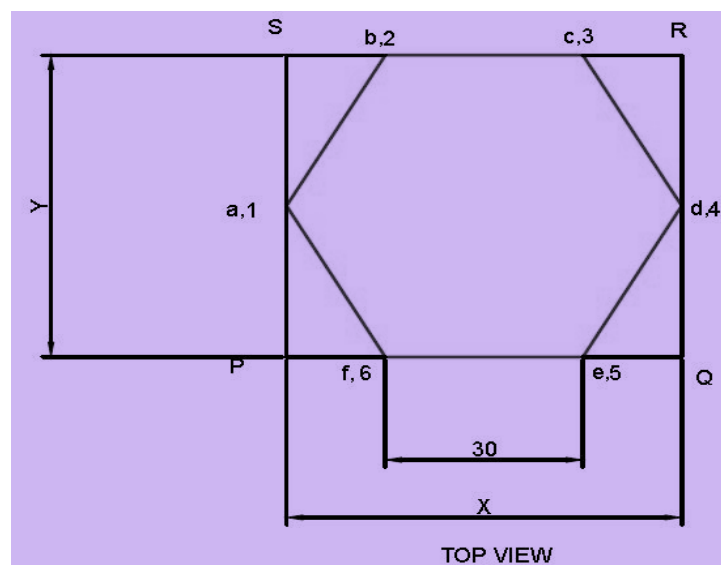
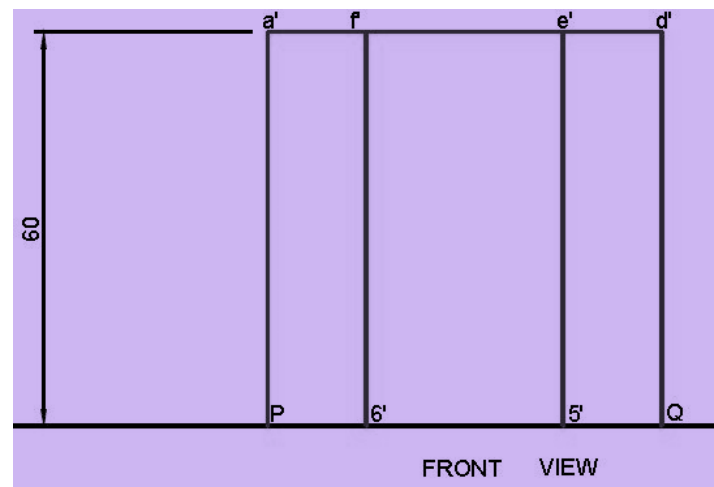
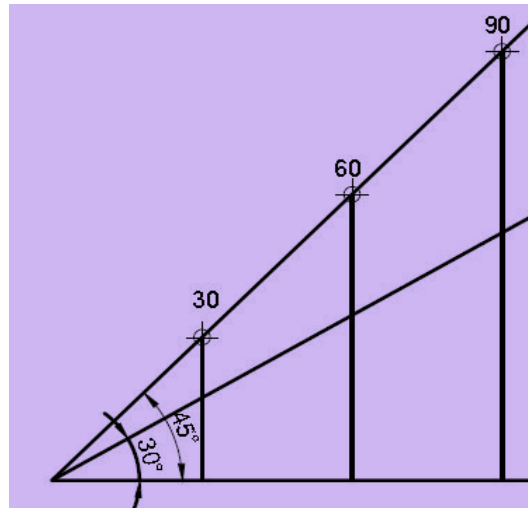
ISOMETRIC PROJECTION : It is drawn by using isometric scale.

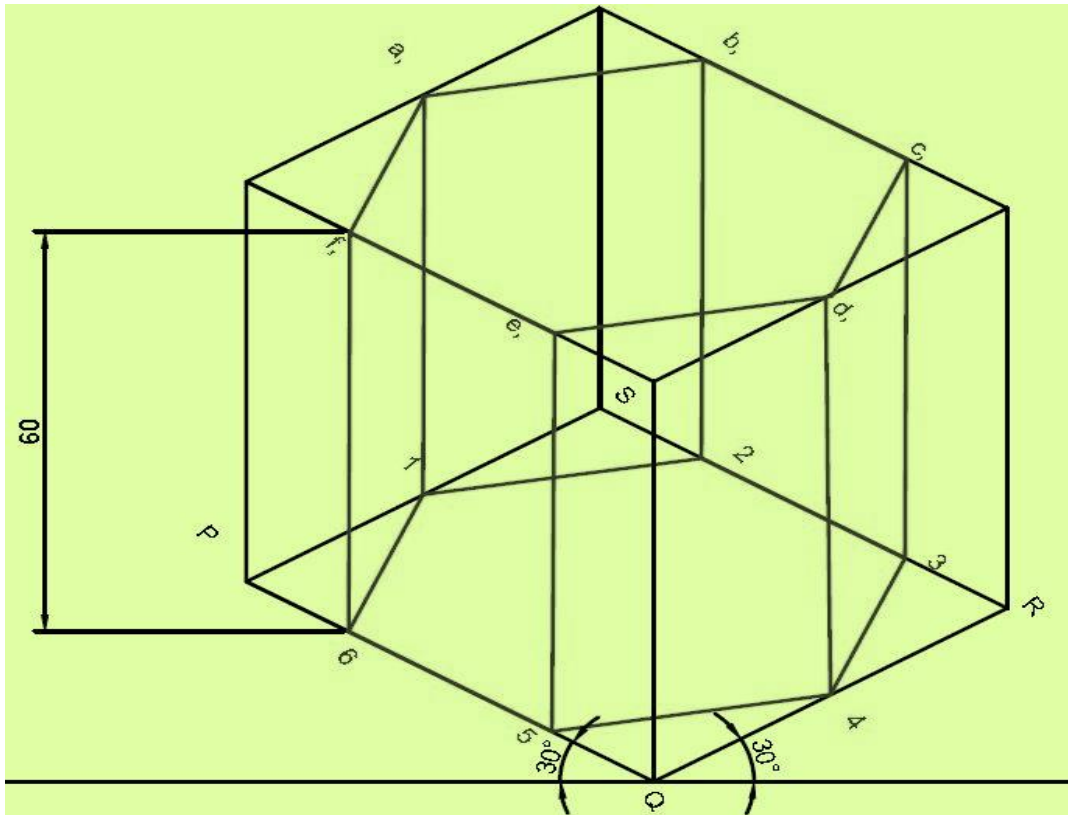
ISOMETRIC VIEW & ISOMETRIC PROJECTION OF PRISM WITH CONSTRUCTION OF ISOMETRIC SCALES :

Q. No.1. A hexagonal prism having the side of base 30 mm and the height of 60 mm is resting on HP and with an edge of the base parallel to VP. Draw its projections and also prepare the isometric view of the prism with axis in vertical position.

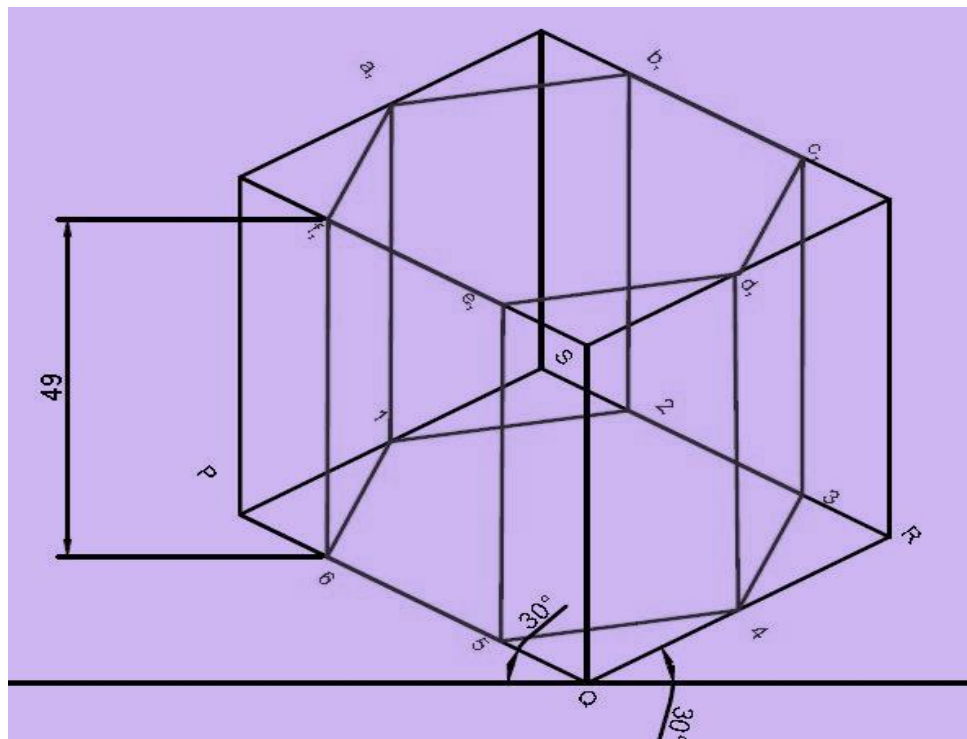
STEPS :

- Draw the true scale and isometric scale as explained to represent the distance.
- Draw the top view of hexagon (a1,b2,c3,d4,e5,f6) with base 30 mm and box it by a rectangle PQRS.
- Draw the front view of the prism with height taken as 60 mm.
- Draw the isometric view of the hexagonal prism with axis in vertical position as shown.
- For the isometric projection take base and height dimension from isometric scale.





ISOMETRIC VIEW



ISOMETRIC PROJECTION

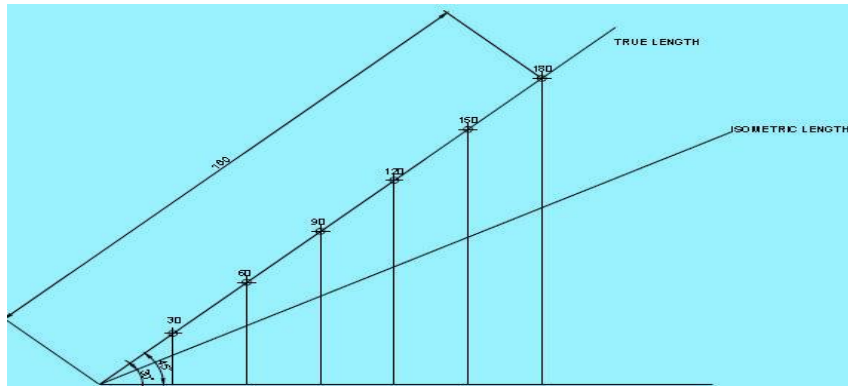
Fig 7.2

ISOMETRIC VIEW & ISOMETRIC PROJECTION OF PYRAMID WITH CONSTRUCTION OF ISOMETRIC SCALES :

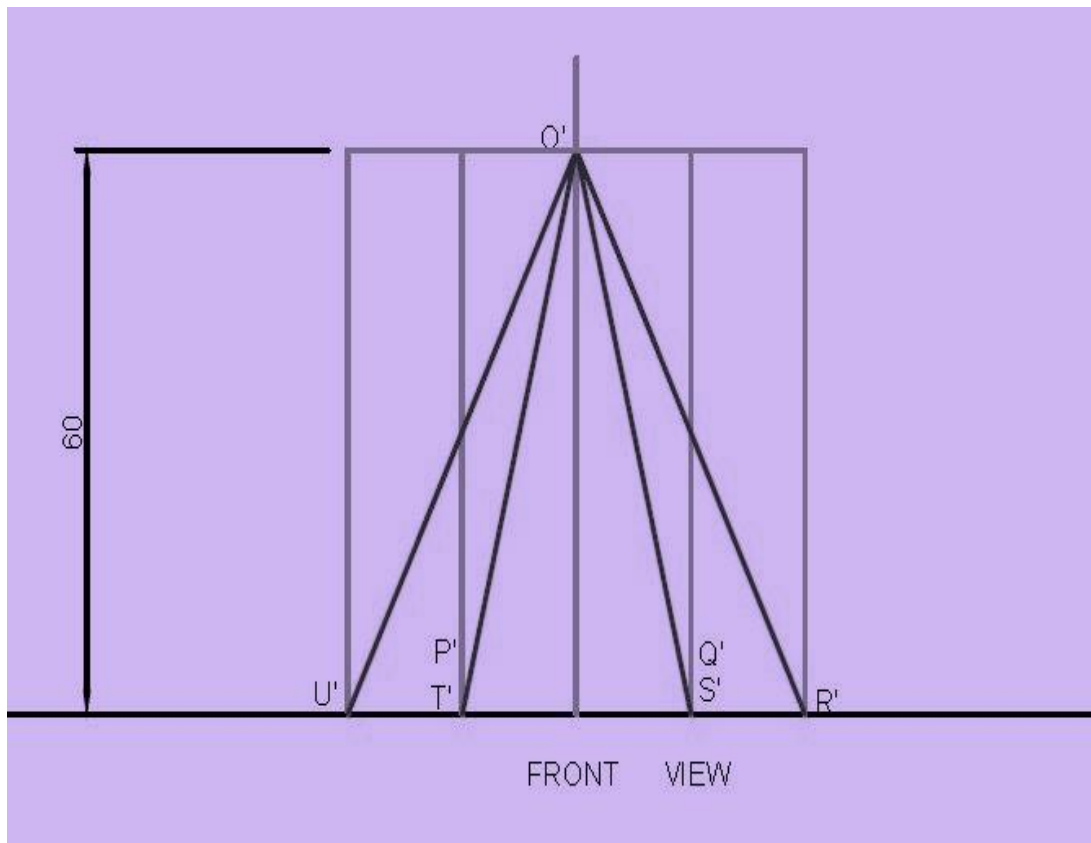
Q. No. 2. A hexagonal pyramid having the side of base 30 mm and the height of 60 mm is resting on HP and with an edge of the base parallel to VP. Draw its projections and also prepare the isometric view of the pyramid with axis in vertical position.

STEPS :

- Draw the true scale and isometric scale as explained to represent the distance.
- Draw the top view of hexagon (PQRSTU) with base 30 mm and box it by a rectangle ABCD.
- Draw the front view of the pyramid with height taken as 60 mm.
- Draw the isometric view of the hexagonal pyramid with axis in vertical position as shown.
- For the isometric projection take base and height dimension from isometric scale.



SCALE



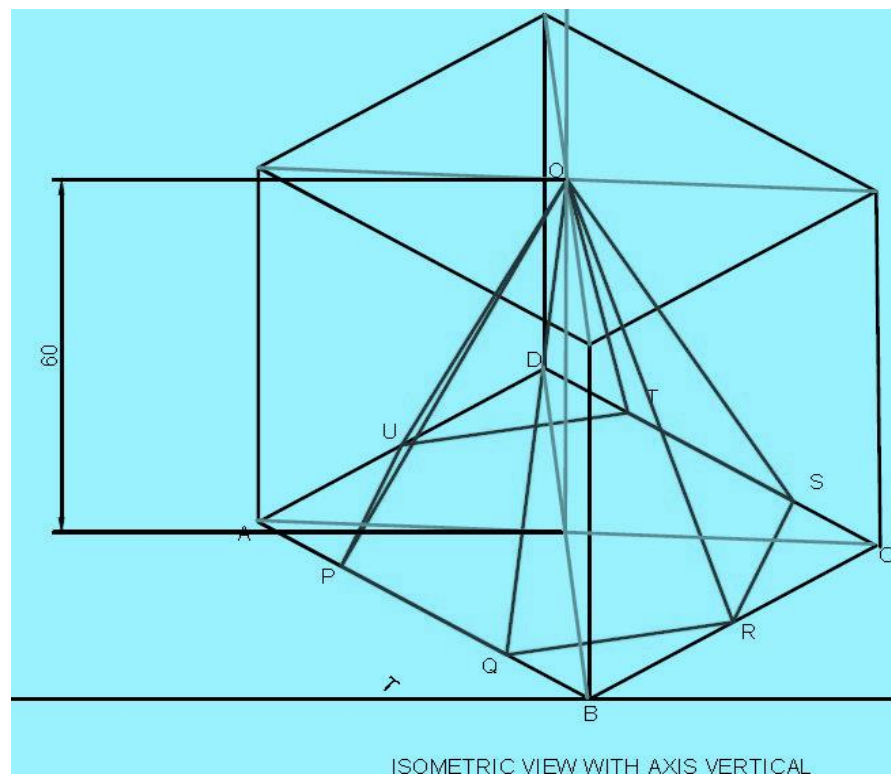
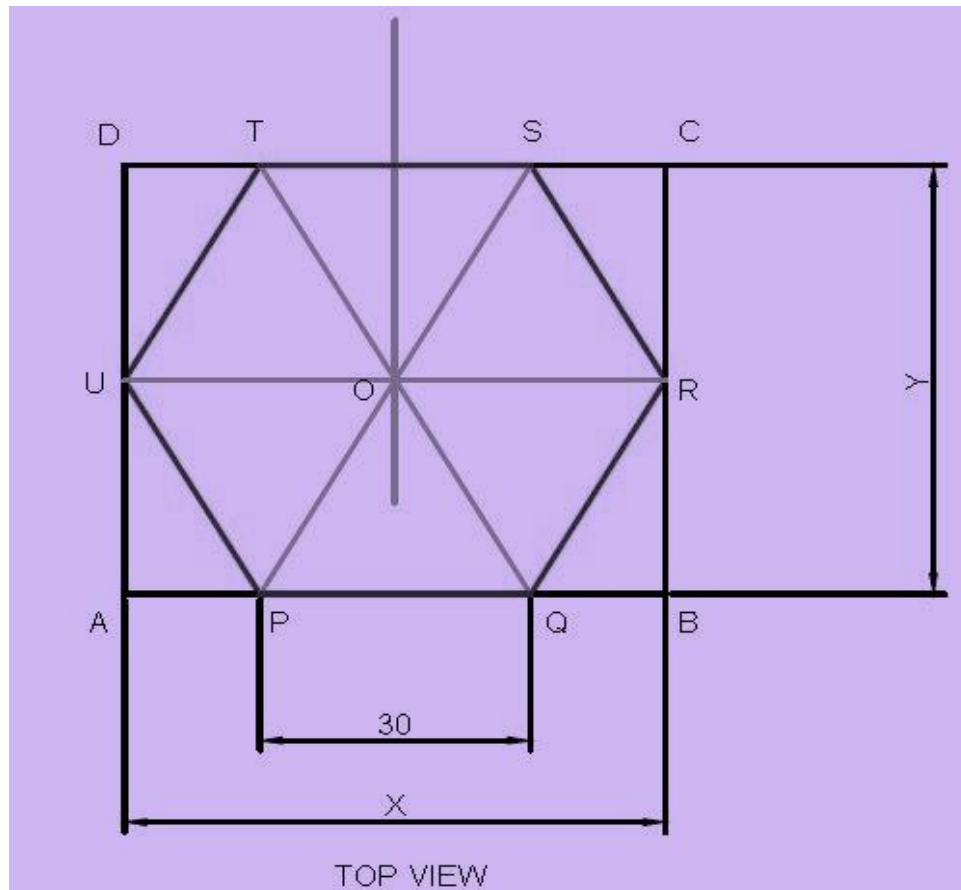


Fig 7.3

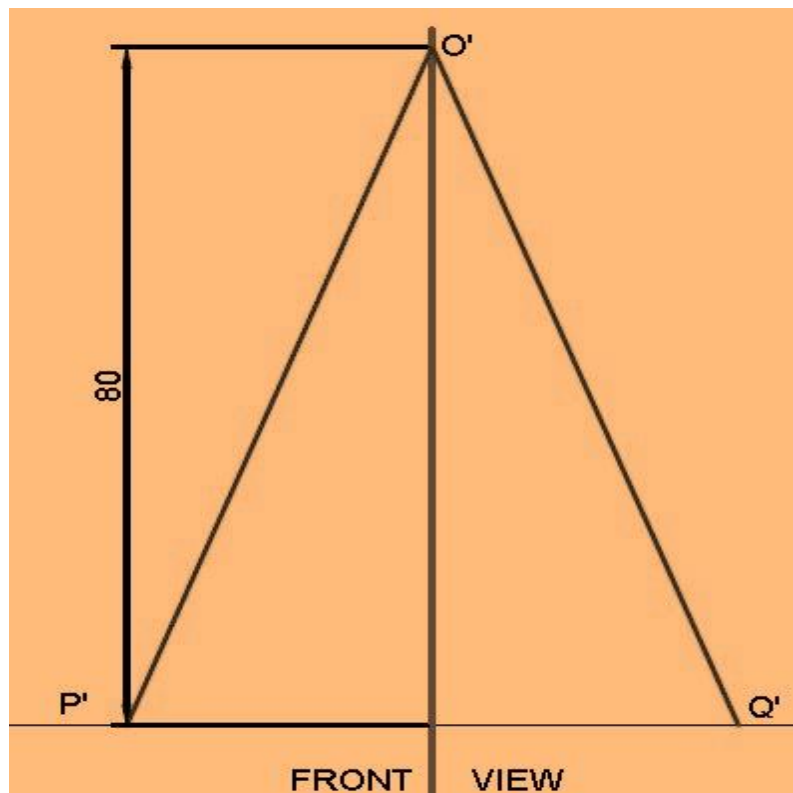
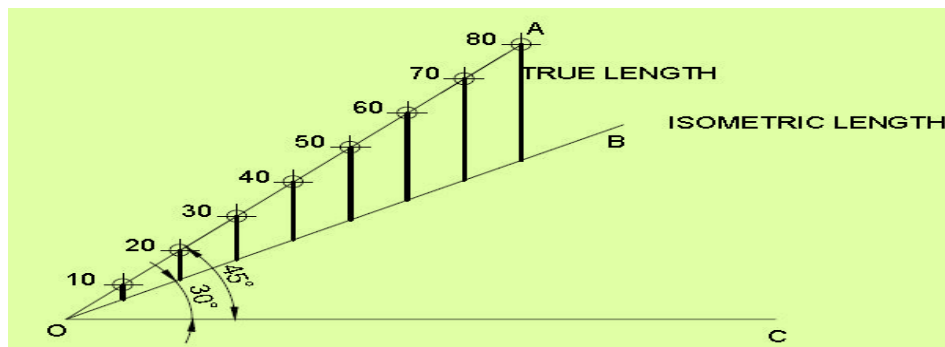
ISOMETRIC VIEW & ISOMETRIC PROJECTION OF CONE WITH CONSTRUCTION OF ISOMETRIC SCALES :

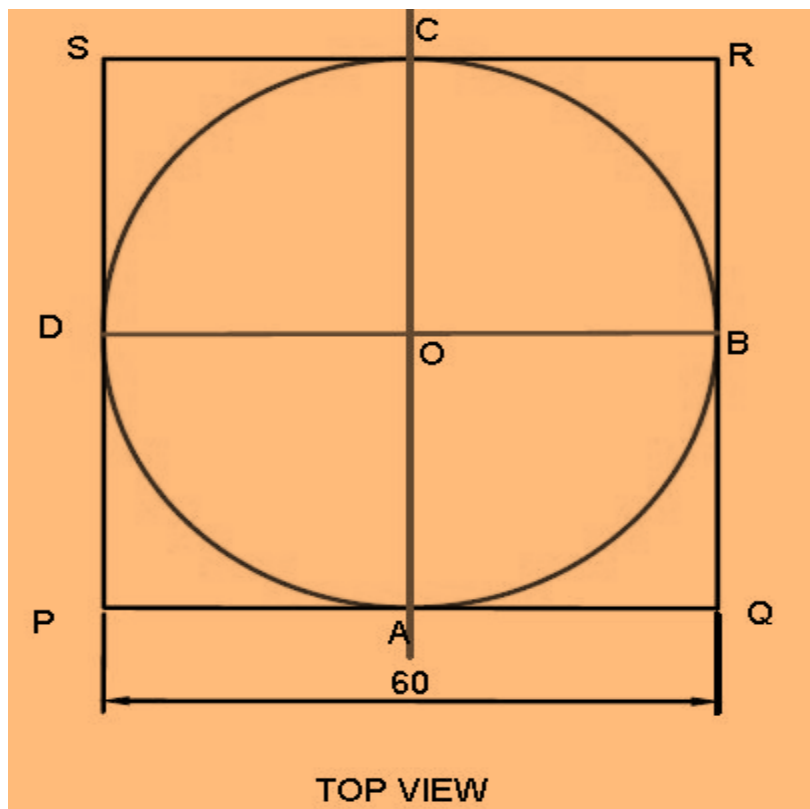
Q.No. 3. A cone having the side of base 60 mm and the height of 80 mm is resting on HP. Draw its projections and also prepare the isometric view of the cone with axis in horizontal position.

STEPS :

- Draw the true scale and isometric scale as explained to represent the distance.
- Draw the top view of cone (ABCD) with base 60 mm and box it by a rectangle PQRS.
- Draw the front view of the cone with height taken as 80 mm.
- Draw the isometric view of the cone with axis in horizontal position as shown. Use four point method to draw circle in isometric view.

For the isometric projection take diameter and height dimension from isometric scale.



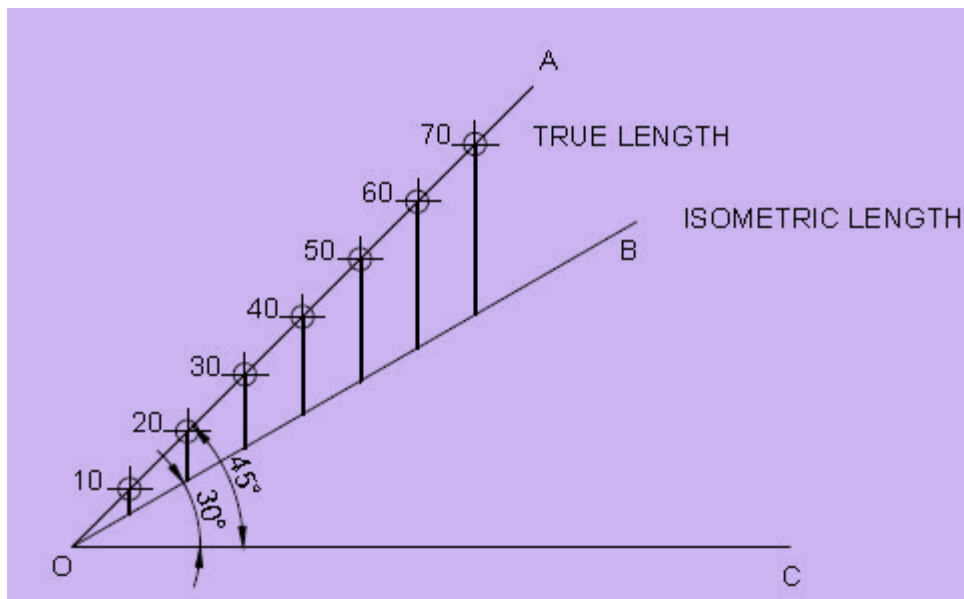


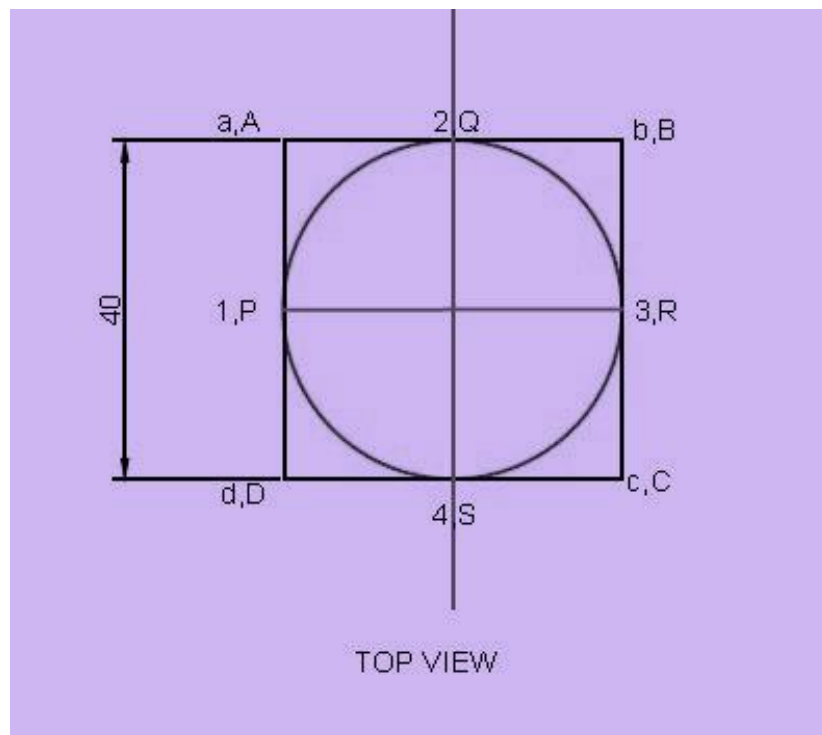
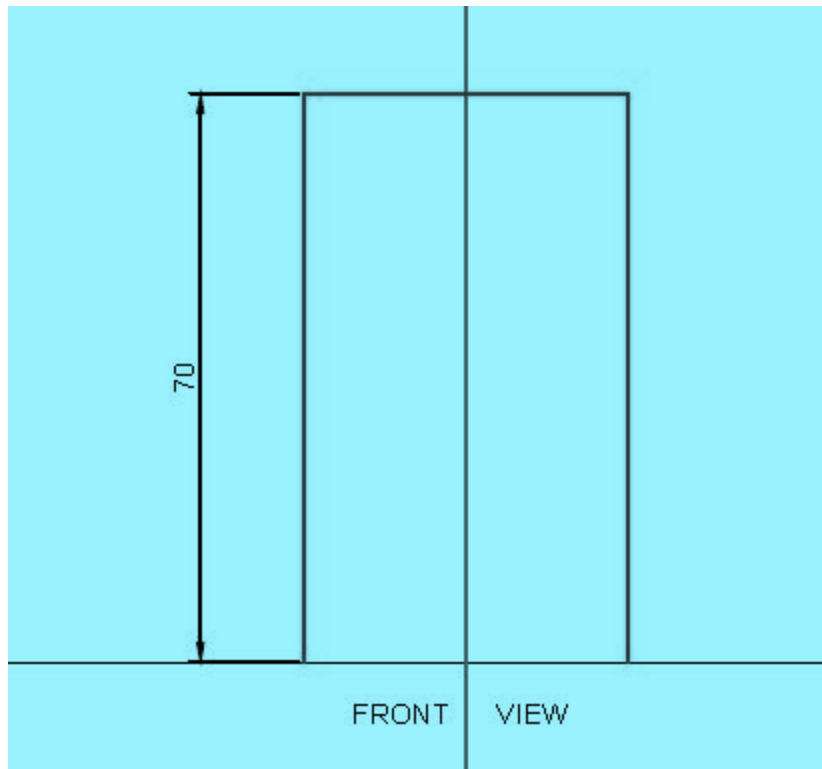
ISOMETRIC VIEW & ISOMETRIC PROJECTION OF CYLINDER WITH CONSTRUCTION OF ISOMETRIC SCALES :

Q.No. 4. A cylinder having the side of base 40 mm and the height of 70 mm is resting on HP. Draw its projections and also prepare the isometric view of the cylinder with axis in vertical position.

STEPS :

- Draw the true scale and isometric scale as explained to represent the distance.
- Draw the top view of cylinder (PQRS) with base 40 mm and box it by a rectangle ABCD.
- Draw the front view of the cylinder with height taken as 70 mm.
- Draw the isometric view of the cylinder with axis in vertical position as shown. Use four point method to draw circle in isometric view.
- For the isometric projection take diameter and height dimension from isometric scale.





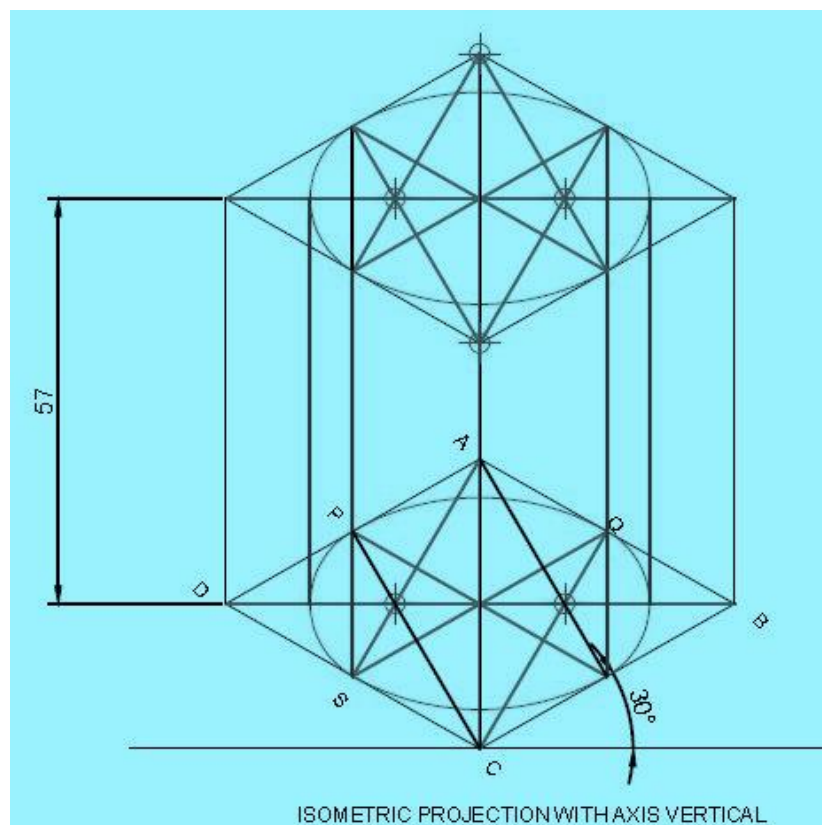
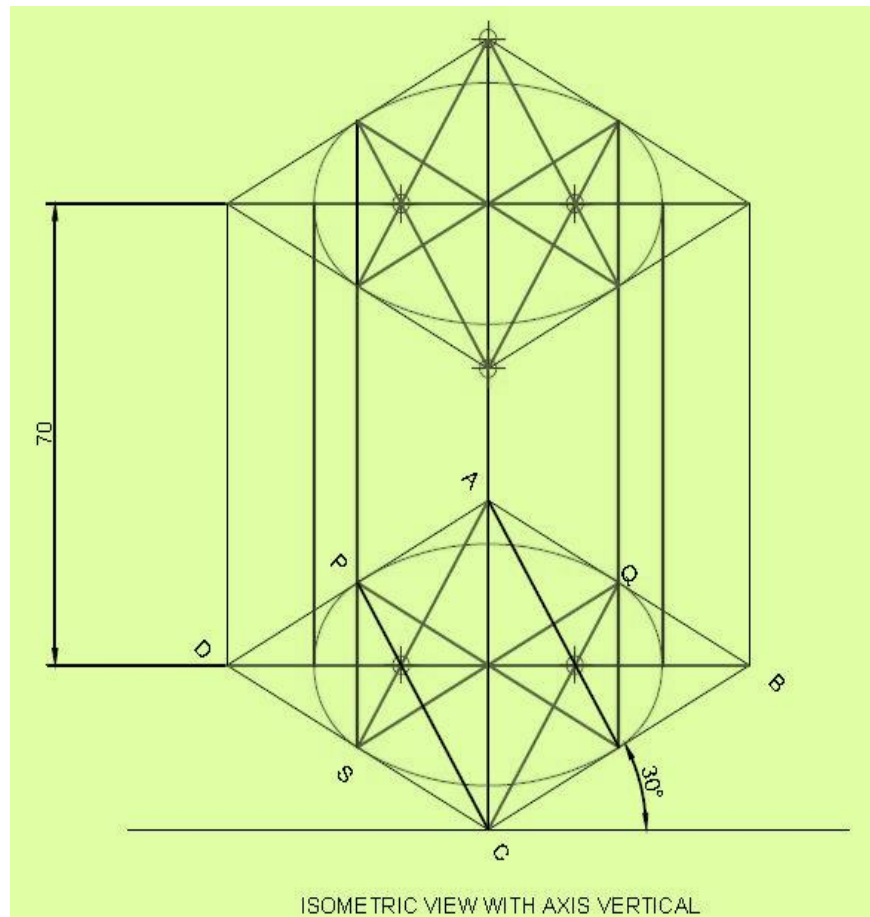


Fig 7.5

EXERCISES

1. Draw the isometric view of a hexagonal pyramid base 45mm edge and axis 65 mm long, having its base on the H.P. and an edge of the base parallel to the V.P.
2. Draw the isometric projection of a regular pentagonal prism side of base 35mm and axis 55mm long resting with its base on V.P. such that one of its rectangular faces is perpendicular to H.P.
3. Draw an isometric view of a cylinder, with a 50mm base diameter and a 70mm long axis when one of the generators is on the HP.
4. Draw an isometric view of a pentagonal pyramid having a base , with a 30 mm side and 50mm long axis when its axis is horizontal.
5. Draw the isometric view of a cone of base 60mm diameter and axis 80mm long ,when its axis is horizontal.
6. Draw the isometric projection of a right circular cone of base diameter 40 mm resting vertically on H.P.
7. Draw the isometric projection of a hexagonal pyramid, side of base 40 mm and axis 70 mm long, when its axis is horizontal.

CHAPTER – 8

BUILDING DRAWING

8.1 TYPES OF BUILDING

1. **Residential Building:** Residential building means a building in which sleeping accommodation is provided for normal residential purposes, with or without cooking or dining facilities, and includes one or more family dwellings, lodging or boarding houses, dormitories, apartment houses, flats .
2. **Non-residential Building:** Non-residential building means a building not used as a dwelling.
3. **Community Hall/ Commercial Building:** Commercial buildings are buildings that are used for commercial purposes, and include office buildings, warehouses, and retail buildings. A commercial building definition is one in which at least 50 percent of its floor space is used for commercial activities, such as retail, the providing of services, or food service (restaurants and the like).

8.2 TERMS RELATED TO BUILDING DRAWING

8.2.1. Line Plan :

- In this drawing, the position and size of internal rooms are given. Such drawing is prepared with a single line. The thickness of the walls is not shown in it.
- The dimension given in the rooms is their internal ones which do not include the thickness of walls.
- The dimension given outside the rooms is their external ones which include the thickness of walls.
- The first dimension represents a horizontal dimension of the room while the second represents a dimension normal to horizontal.
- To represent the height of a room, it is written in a circle.
- The doors and windows are represented in the related places with size.
- The details given in the line diagram are used to draw the building drawing.

8.2.2. Plan :

1. In this type of building drawing the size, arrangement, and position of rooms and veranda is shown.
2. Plan is generally the top view of the building.
3. It is obtained by cutting the building at window sill level by a horizontal cutting plane and then, removing the upper part of the building and then, the top view of remaining is projected on the horizontal plane (HP).

8.2.3. Elevation :

- Elevation or front view is the outward view of a completed building along any side of the building. When a building is seen by standing in front of it, the view that can be viewed is projected on the vertical plane (VP) is called front elevation.
- Similarly backside view is called rear elevation or from any side of it which is known as side elevation.

8.2.4. Section:

- Section is also known as vertical section and sectional elevation or cross section.
- It is imagined that a finished buildings is cut vertically along a line so that the building is separated into two portions along the imagined vertical plane right from top of the building to the lowest part of foundation.
- The view that can be seen while travelling along this imaginary vertical plane when looking towards left is drawn to the same scale as that adopted for the plan.

8.3 TERMS RELATED TO BUILDING

8.3.1. Sub-Structure :

1. The portion of the building or structure, which lies below the ground level, is termed as substructure also called foundation.

8.3.2. Super-Structure :

1. The portion of the building or structure, which lies above the ground level, is termed as superstructure.

8.3.3. Plinth :

1. The portion of a building between ground level (GL) and floor level (FL) is called plinth/plinth wall and the height is called plinth height.
2. If the thickness of plinth wall is more than super-structure wall, then the projected portion of the plinth wall from the super-structure wall is called plinth projection.
3. Generally plinth height of 450mm/600mm is provided.

8.3.4. Lintel :

1. 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.
2. Its size depends on the opening size of doors/windows/verandah. In some cases it is provided throughout the wall.
3. Depth of lintel is generally of 150mm.

8.3.5. Chajja/Sun shade :

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

8.3.6. Ceiling Height:

1. The height of room from the floor level to the soffit of ceiling is called ceiling height.

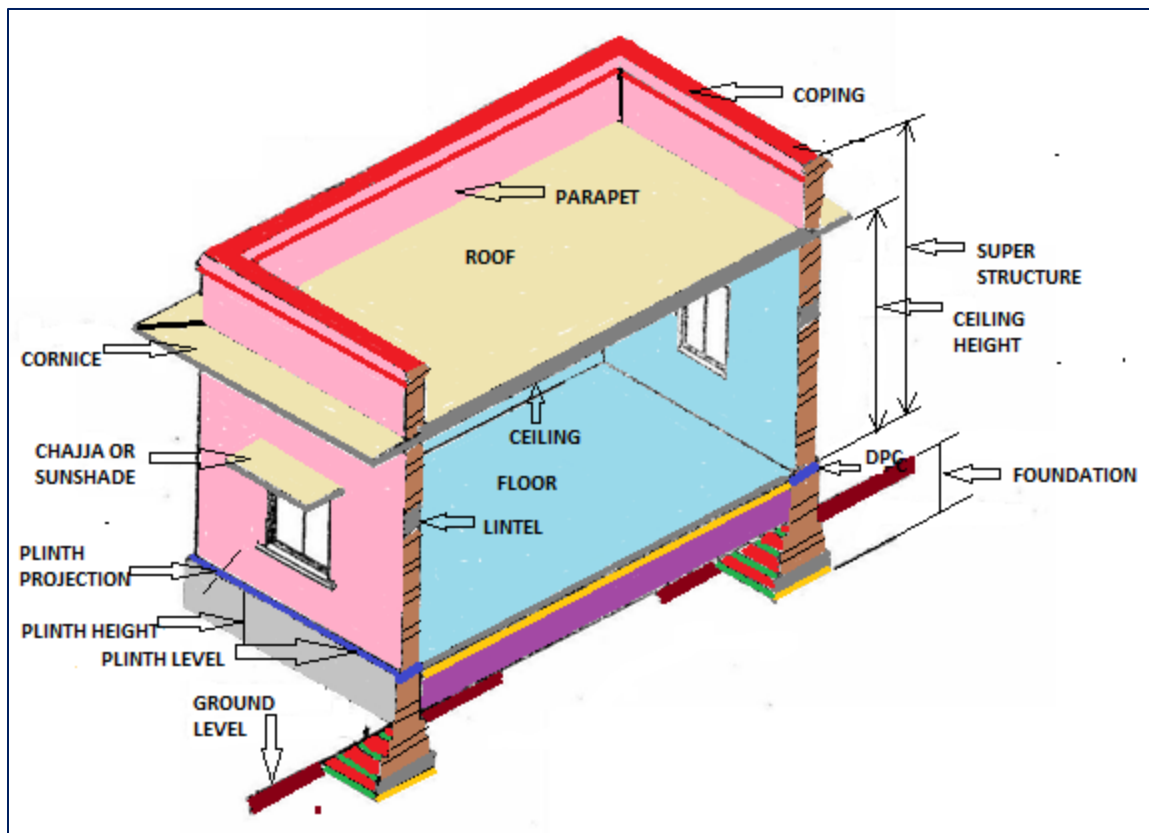


Figure 8.1: Main Parts of One Storied Building

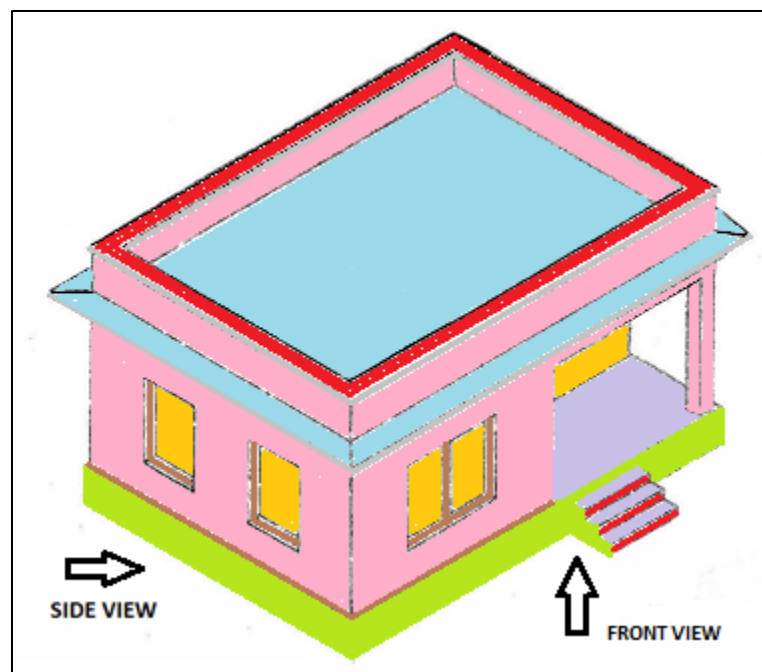


Figure 8.2 : Front View and Side View

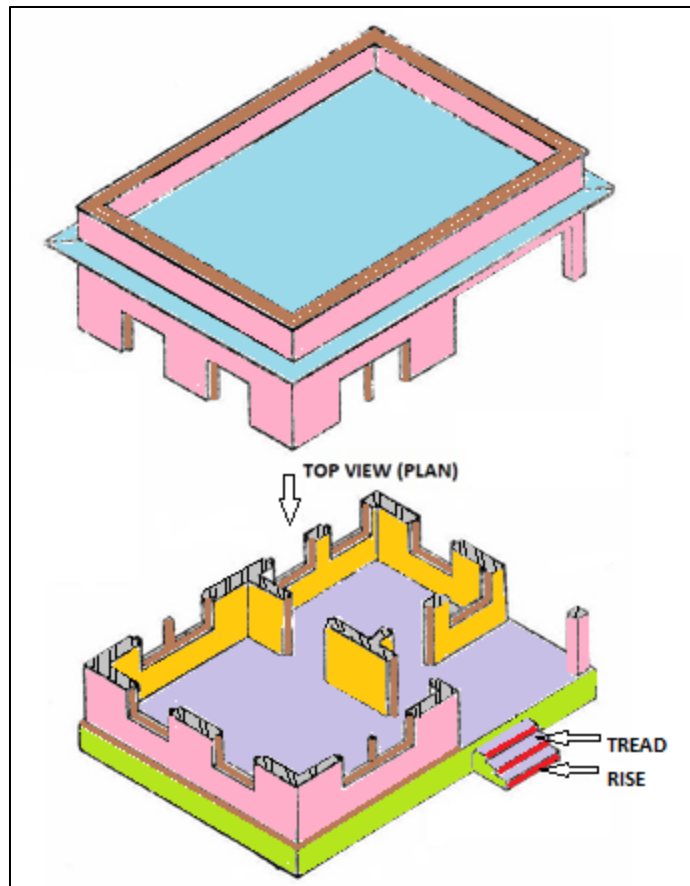


Figure 8.3: Top View

Q. No. 1.

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

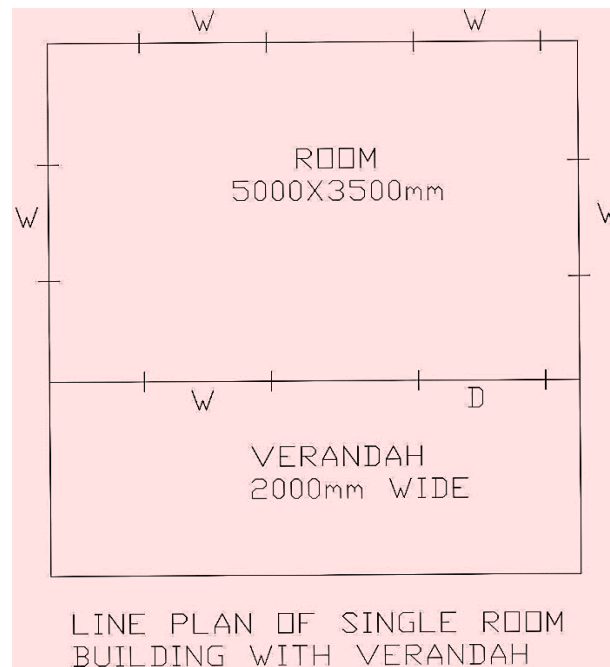


Figure 8.3

Specifications :

1. Wall Thickness – 300 mm
2. Plinth height – 600 mm
3. Plinth thickness – 400 mm
4. Steps
 - i. Trade – 300 mm
 - ii. Riser – 150 mm
5. Ceiling Height for room and verandah – 3000 mm
6. Masonry pillars – 300 mm X 300 mm
7. Spacing of masonry pillars should not exceed 3000 m
8. Roof slab thickness – 120 mm
9. Roof slab projection (cornice) – 120 mm
10. Chajja
 - i. Thickness – 75 mm
 - ii. Width – 450 mm
11. Size of Doors and Windows
 - i. Window(W) – 1200 mm X 1350 mm
 - ii. Door(D) – 1200 mm X 2100 mm
12. Size of chaukath for doors and windows – 80 mm X 100 mm

Solution :**Steps for drawing Plan**

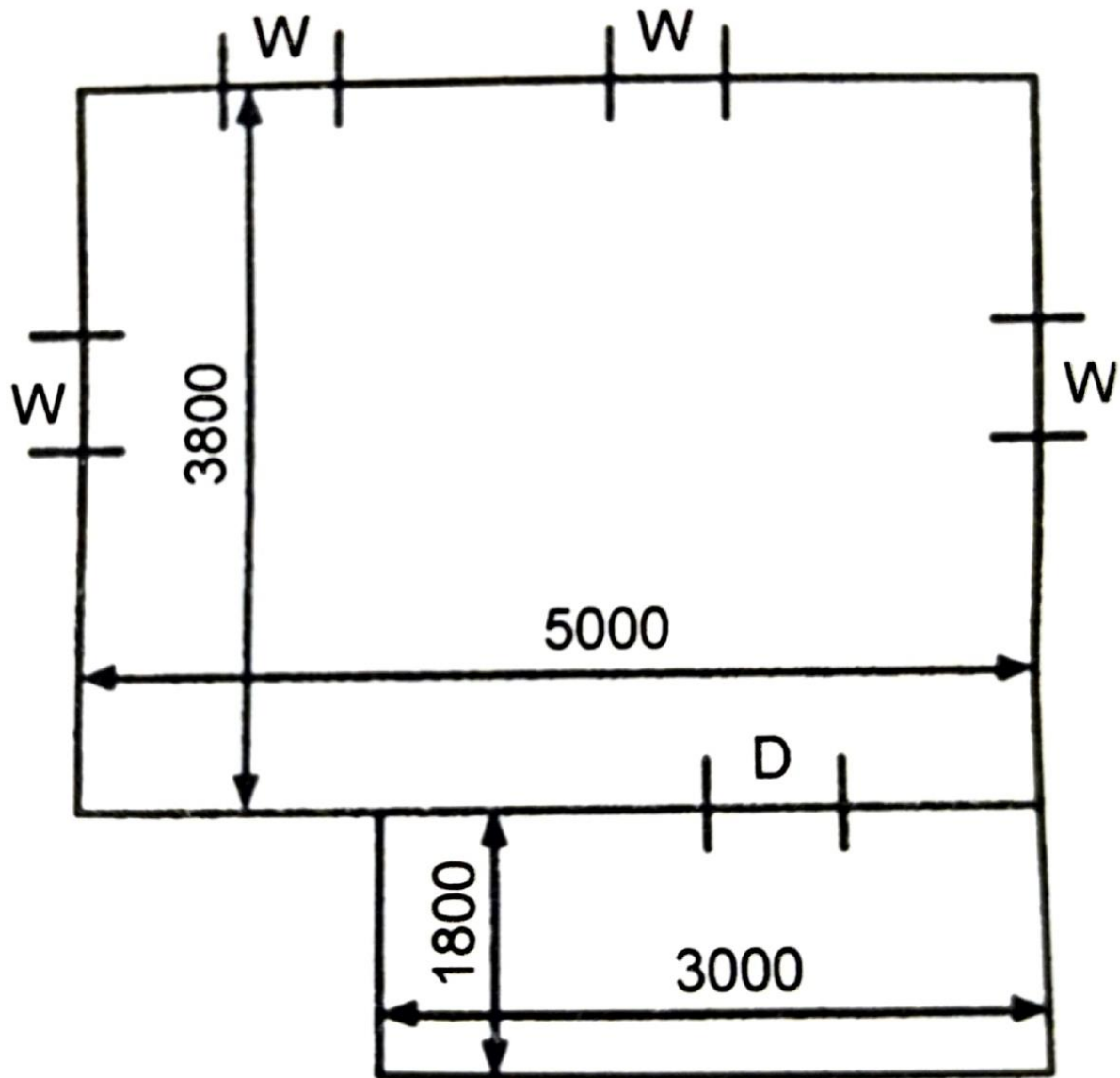
1. First of all choose a suitable scale then convert all the dimensions as per the scale.
2. After that, imagine that the building is cut by a horizontal plan at window sill level and after removing the top portion remaining portion is the plan.
3. Then, the various elements of the building like the wall, widows, door, column, step etc. are projected on a horizontal plan (HP) keeping it below the reference line (XY) as per the principle of first angle projection which is the required plan as shown in the figure 8.4 in next page.
4. 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) for example, the chajja or sun shade.

Steps for drawing Elevation

- 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 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. The required elevation is as shown in the figure 8.4 in the next page.

Q. No. 2.

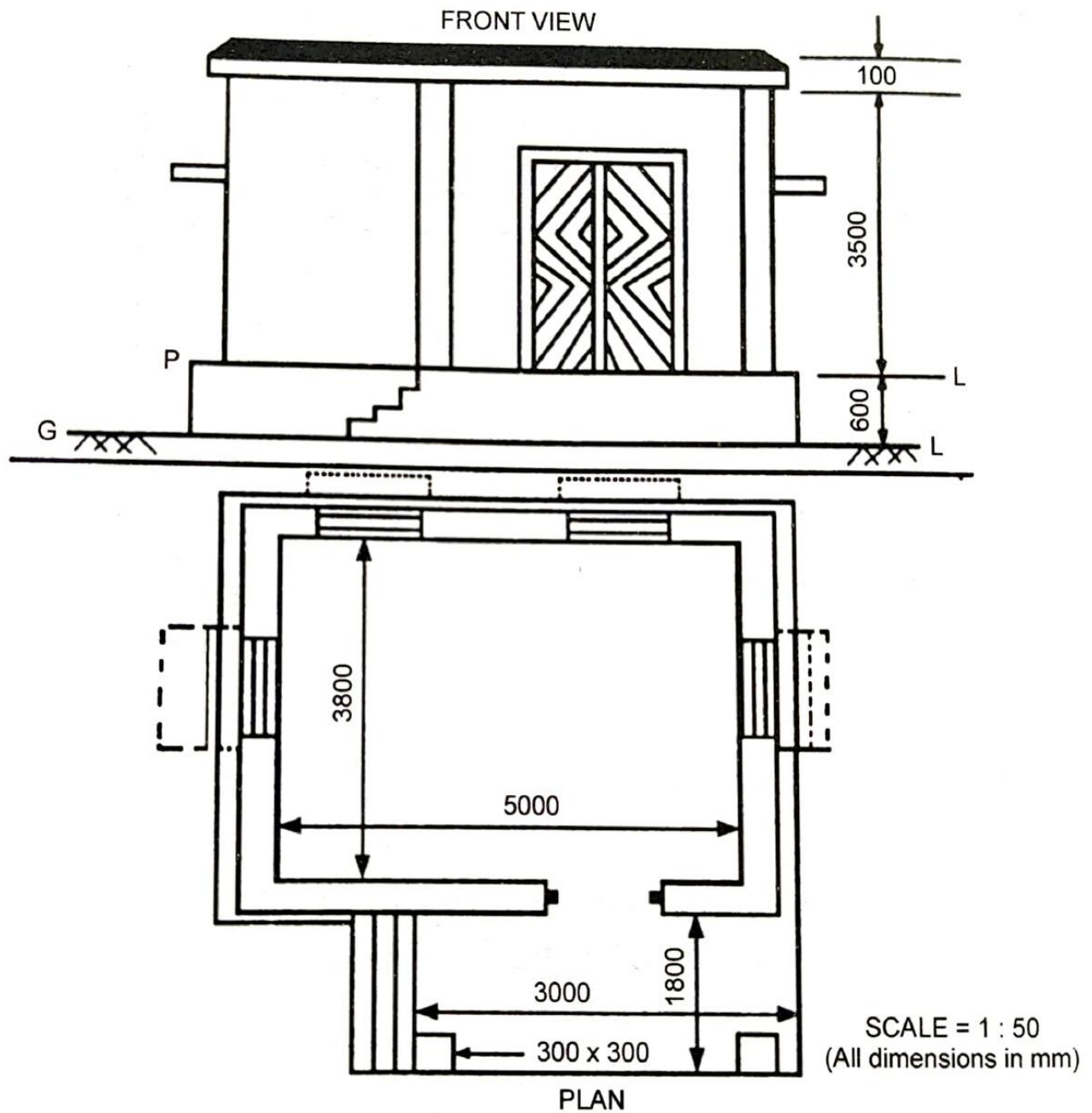
Draw the plan and elevation of the building from the line plan and specifications as given below.



Specifications:

- Wall Thickness – 300mm
- Plinth height – 600mm
- Steps
 1. Trade – 250mm
 2. Riser – 150mm
- Ceiling Height for room and verandah – 3500mm
- Masonry pillars – 300mm X 300mm
- Spacing of masonry pillars should not exceed 3000m
- Roof slab thickness – 100mm

- Thickness of weathering coat = 80 mm
- Chajja projection = 450mm



EXERCISES

Q1. Draw the plan and elevation of the building having size of room as 6000 mm X 3500 mm and specifications as given below.

Specifications :

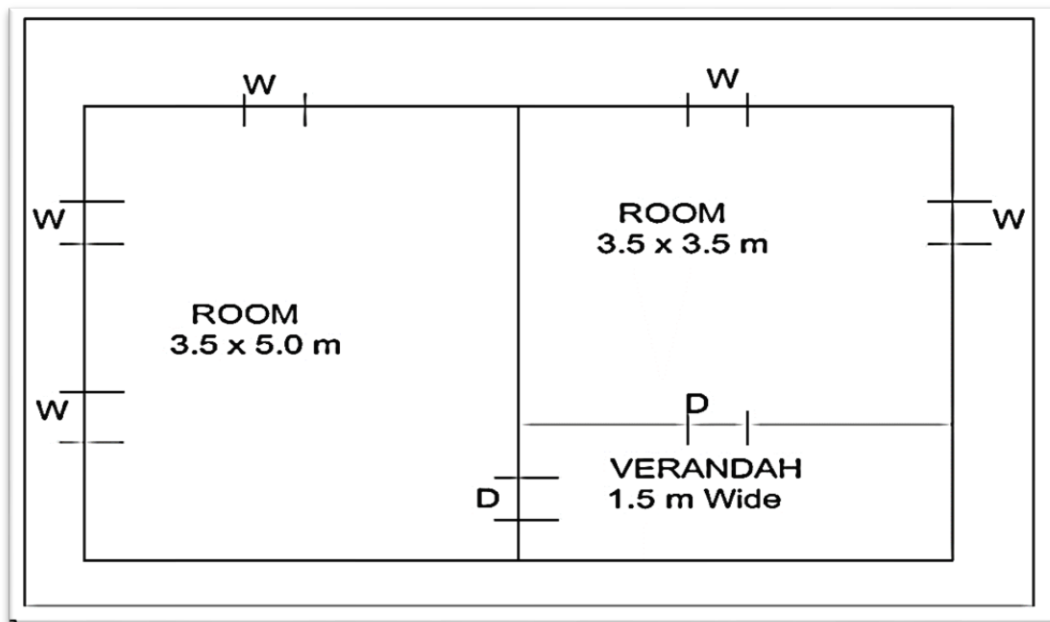
- Wall Thickness – 300mm
- Plinth height – 450mm
- Plinth thickness – 400mm
- Steps
 3. Trade – 300mm
 4. Riser – 150mm
- Ceiling Height for room and verandah – 3000mm
- Masonry pillars – 300mm X 300mm
- Spacing of masonry pillars should not exceed 3000m
- Roof slab thickness – 100mm
- Roof slab projection (cornice) – 100mm
- Chajja
 - Thickness – 80mm
 - Width – 450mm
- Size of Doors and Windows
 - Window(W) – 1200mm X 1400mm
 - Door(D) – 1200mm X 2100mm
- Size of chaukath for doors and windows – 75mm X 100mm
- Width of Verandah – 2000mm

Q2. Draw the plan and elevation of the building as per given line plan with the specifications as given below.

Specifications :

- Wall Thickness – 300mm
- Plinth height – 600mm
- Plinth thickness – 400mm
- Steps
 - Trade – 300 mm
 - Riser – 150 mm
- Ceiling Height for room– 3300mm
- Ceiling Height for verandah-2500mm
- Masonry pillars – 300mm X 300mm

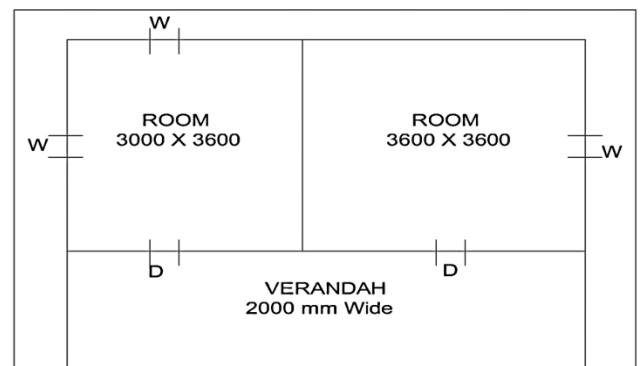
- Roof slab thickness – 120mm
 - Roof slab projection (cornice) – 100mm
 - Chajja
 - Thickness – 80mm
 - Width – 480mm
 - Size of Doors and Windows
 - Window(W) – 1200mm X 1500mm
 - Door(D) – 1200mm X 2100mm
 - Size of chaukath for doors and windows – 80mm X 100mm
- Assume any other data if necessary



Q3. Draw the plan and elevation of the building as per given line plan with the specifications as given below.

Specifications :

- Wall Thickness – 300mm
- Plinth height – 450mm
- Plinth thickness – 400mm
- Steps
 - Trade–300mm
 - Riser – 150mm
- Ceiling Height for room– 3000mm
- Ceiling Height for verandah-2200mm
- Masonry pillars – 300mm X 300mm



- Roof slab thickness – 150mm
 - Roof slab projection (cornice) – 100mm
 - Chajja
 - Thickness – 80mm
 - Width – 500mm
 - Size of Doors and Windows
 - Window (W) – 1000mm X 1500mm
 - Door (D) – 1200mm X 2100mm
 - Size of chaukath for doors and windows – 80mm X 100mm
- Assume any other data if necessary.

CHAPTER – 9

PRACTICES ON AUTOCAD

9.1 INTRODUCTION

In a little over a generation's time the methods used to create technical drawings have fundamentally changed from using pencil and paper to the use of Computer Aided Drafting, better known as CAD. The analog world of drafting boards, T squares, triangles, and even the romantic french curve has given way to the brave new digital world of computers. Using CAD, you can draw something once and copy it hundreds, or even thousands, of times. Changing a design can be as simple as pushing a button. Drawings can be shared instantaneously across the room or even around the world over a computer network. Developed and marketed by Autodesk, **AutoCAD** was first released in December 1982 as a desktop app running on microcomputers with internal graphics controllers. It has been subsequently revised and up-graded.

9.2 LAUNCHING OR OPENING AUTOCAD

Starting AutoCAD You can start AutoCAD by either double clicking on the program Icon on the desktop or by clicking on the program name in the Start menu. The program will start and after a minute or so should display a screen similar to the one shown below.

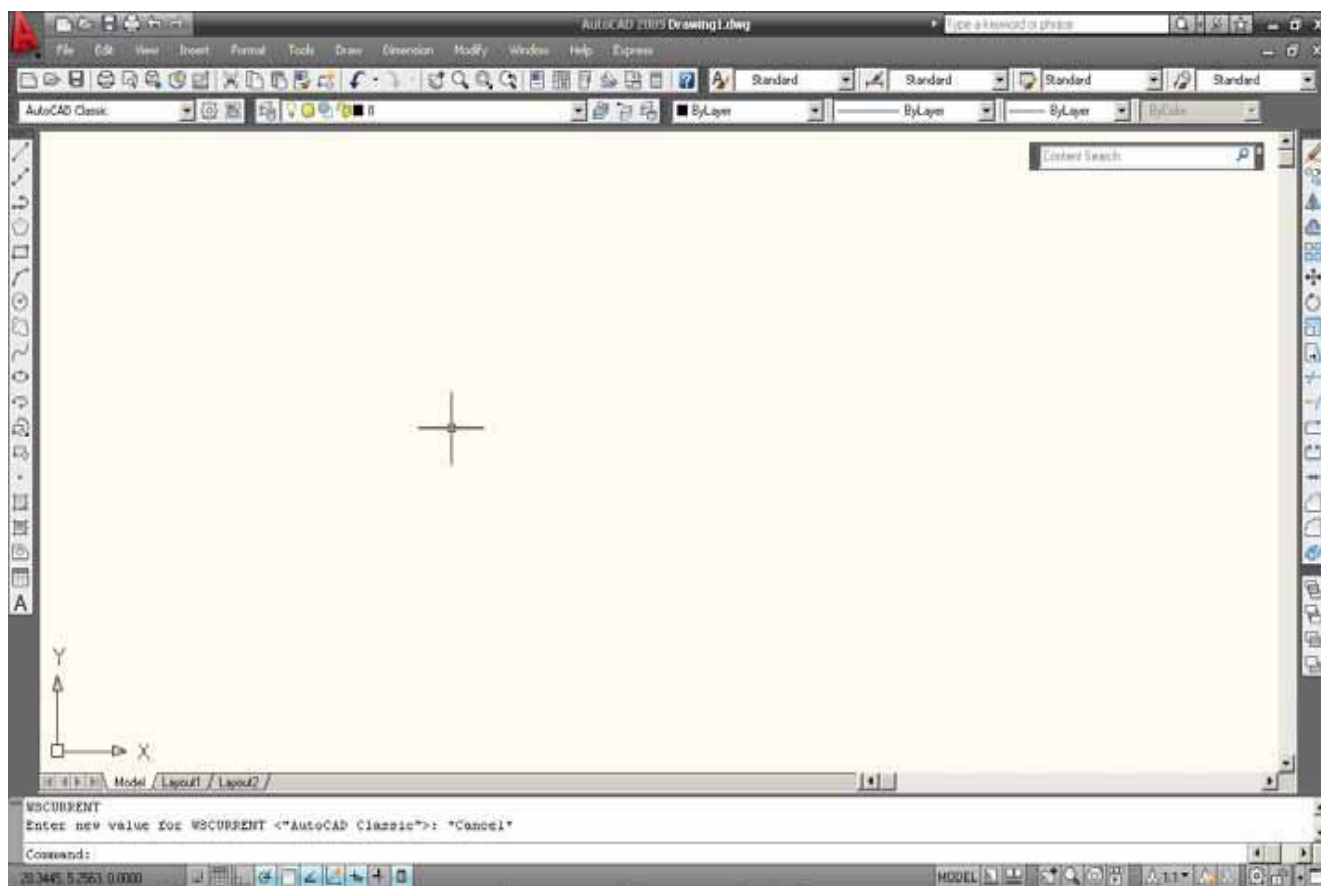


Fig 9.1

9.3 POINTING DEVICE MOUSE

AutoCAD uses either a mouse or digitizing tablet to select objects in a drawing.

9.3.1 Left Mouse Button

Used to pick or select objects.

1. Click the left mouse button to select an object area in the drawing.
2. Press **ESC** twice to deselect an object (or to cancel a command).

9.3.2 Right Mouse Button

Used to enter a command, repeat last command, or access shortcut menus.

1. Click the right mouse button.

TIPS : SHIFT + the right mouse button brings up the object snap menus.
Various screen locations for the mouse brings up different menus.

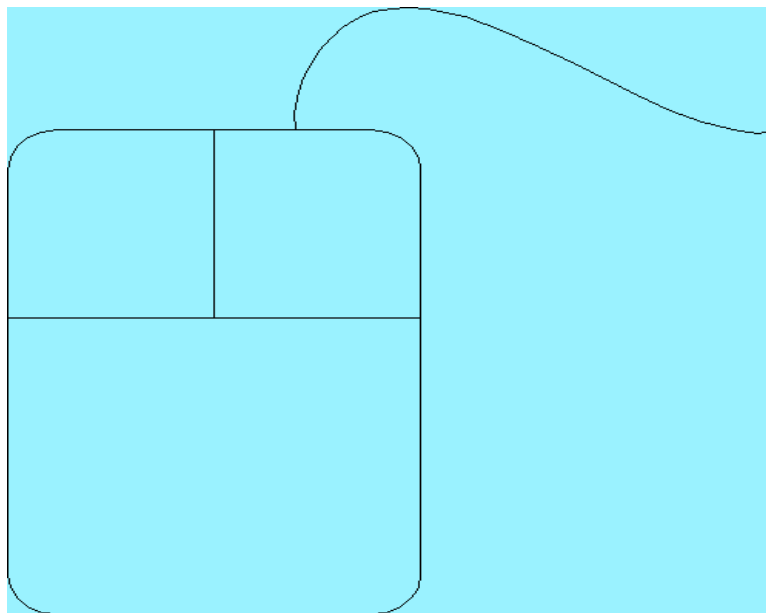


Fig 9.2

9.4 TYPING COMMANDS

All AutoCAD commands can be typed in at the command line. Many commands also have one or two letter aliases that can also be typed as shortcuts to the commands.

Command : **LINE**

1. Type the desired command at the command prompt. or
2. Type the command's alias. Command: **L**
3. Press **ENTER/Space** to end.
4. Type an option at the command prompt.

TIP : Many AutoCAD commands require you to press ENTER to complete the command. You know you are no longer in an AutoCAD command when you see a blank command line.

9.4.1 Reusing the Last Command

The last used AutoCAD command can be re-entered by one of the following three methods of ENTER. The ENTER key on the keyboard will always act as ENTER, the SPACEBAR and RIGHT MOUSE will act as enter most of the time (exceptions include placing TEXT).

1. Press the **ENTER** key on the keyboard or
2. Press the **Space bar** on the keyboard. or
3. Click the **right** mouse button.

9.4.2 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.

9.4.3 Quick access toolbar :

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

9.5 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 work spaces are defined in Autocad. Those are

1. Drafting & Annotation
2. 3D Modeling
3. 3d basics
4. AutoCAD Classic

9.5.1 Function Keys and Accelerator Keys

F1	Displays Help
F2	Toggles Text Window
F3	Toggles OSNAP
F4	Toggles TABMODE
F5	Toggles ISOPLANE
F6	Toggles UCSDETECT
F7	Toggles GRIDMODE
F8	Toggles ORTHOMODE
F9	Toggles SNAPMODE
F10	Toggles Polar Tracking
F11	Toggles Object Snap Tracking
F12	Toggles Dynamic Input

ALT+F11	Displays the Visual Basic Editor
ALT+F8	Displays the Macros dialog box
CTRL+0	Toggles Clean Screen
CTRL+1	Toggles Properties palette
CTRL+2	Toggles DesignCenter
CTRL+3	Toggles the Tool Palettes Window
CTRL+4	Toggles Sheet Set Manager
CTRL+5	Toggles Info Palette
CTRL+6	Toggles dbConnect Manager
CTRL+7	Toggles Markup Set Manager
CTRL+8	Toggles the QuickCalc calculator palette
CTRL+9	Toggles the command window
CTRL+A	Selects objects in drawing
CTRL+SHIFT+A	Toggles Groups
CTRL+B	Toggles Snap
CTRL+C	Copies objects to Clipboard
CTRL+SHIFT+C	Copies objects to Clipboard with Base Point
CTRL+D	Toggles Dynamic UCS
CTRL+E	Cycles through isometric planes
CTRL+F	Toggles running object snaps
CTRL+G	Toggles Grid
CTRL+H	Toggles PICKSTYLE
CTRL+I	Toggles COORDS

Table 9.1

9.6 LIMITS

Sets an invisible rectangular boundary in the drawing area that can limit the grid display and limit clicking or entering point locations.

The following prompts are displayed.

Lower-Left Corner

Specifies the lower-left corner for the drawing limits.

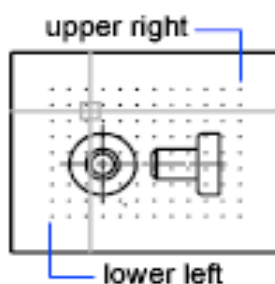


Fig 9.3

Upper right corner

Specifies a point in the drawing area that represents the opposite corner of the rectangular limits boundary.

On

Turns on limits checking. When limits checking is on, you cannot enter points outside the grid limits. Because limits checking tests only points that you enter, portions of objects such as circles can extend outside the grid limits.

Off

Turns off limits checking but maintains the current values for the next time you turn on limits checking.

9.7 UNITS

To change units in a drawing:

1. Type in **UNITS** on the command line.
2. Select Architectural under the first drop-down menu and then click OK.

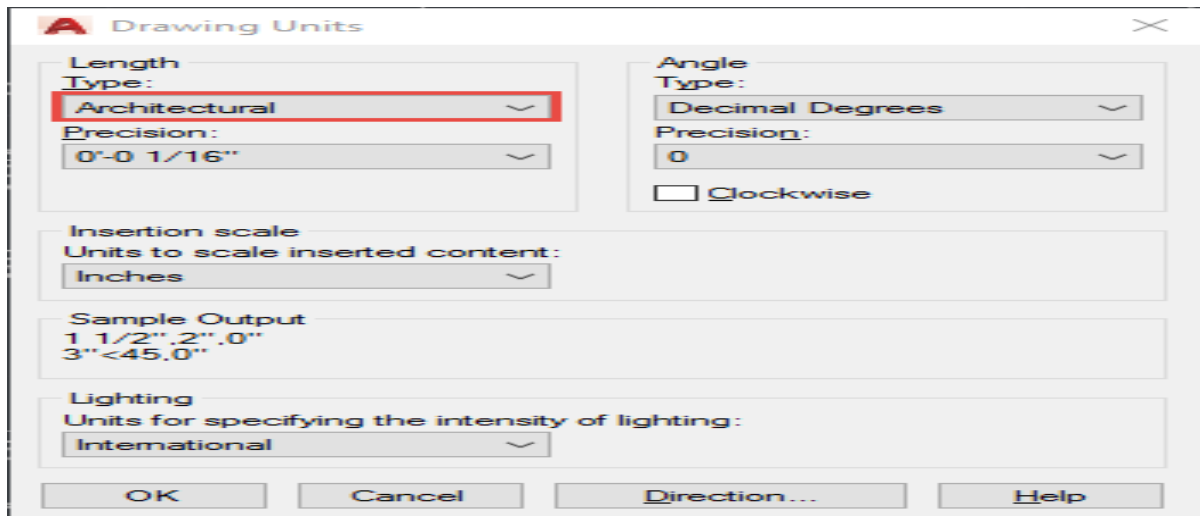


Fig 9.4

9.8. DRAW COMMANDS

9.8.1. Line Command

Creates single straight line segments

1. **Choose** Draw Line.
or
2. **Click** the Line icon. 
- or
3. **Type** LINE from the command prompt
Command : **LINE** or **L**
4. **Press** ENTER
5. **Pick** From point : (**point**)

6. **Pick** Specify next point or[Close / Undo] : **(point)**
7. **Pick** Specify next point or[Close / Undo] : **(point)**
8. **Press** ENTER to end line sequence
- or
9. **Type** U to undo the last segment
To point : **U** (undo)
- or
10. **Type** C to create a closed polygon
To point : **C** (close)

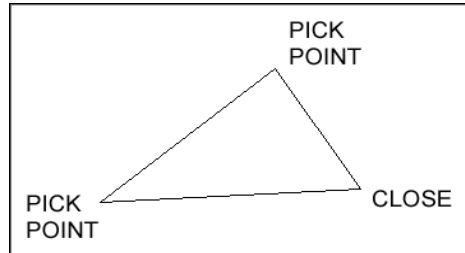
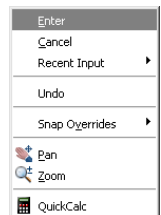


Fig 9.5

TIPS :

- You can continue the previous line or arc by responding to the From point: prompt with a space or ENTER.
- Choose the right mouse button for the line pop-up menu to appear while in the line command.



9.8.2 Circles

Circle Command

1. **Choose** Draw, Circle.
- or
2. **Click** the Circle icon. 
- or
3. **Type** CIRCLE at the command prompt.
Command: **CIRCLE**
4. **Type** One of the following options:
3P/2P/TTR/⟨⟨center point⟩⟩:
- or
5. **Pick** A center point.
6. **Type** A radius or diameter.
- or
7. **Pick** A radius or diameter Diameter/⟨⟨radius⟩⟩:

TIPS :

- To create circles that are the same size, press ENTER when asked for the circle radius.
- When selecting a circle with a pickbox, be sure to select the circumference of the circle.

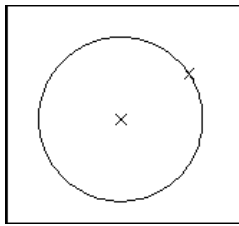


Fig 9.6 (a)

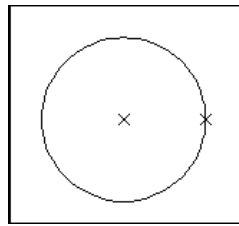


Fig 9.6 (b)

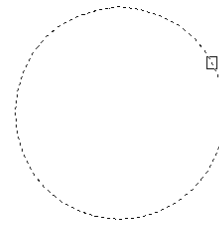
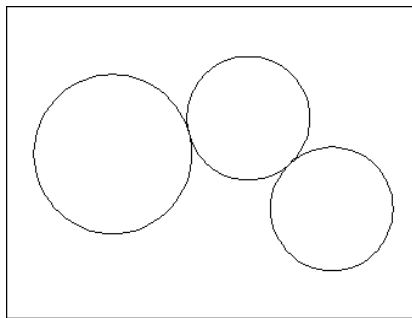


Fig 9.6 (c)

Circle, Center Radius Circle, Center Diameter Circle, Tangent, Tangent Radius

**9.8.3 Arc Command****1. Choose**

Draw, Arc.

or

Click the Arc icon. or

ARC at the command prompt

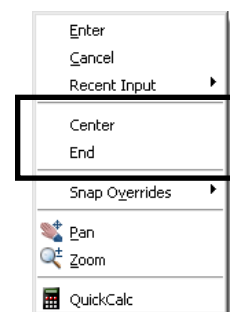


Command: **ARC**

3. Draw

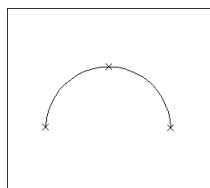
One of the arcs.

- Except for 3 point arcs, arcs are drawn in a COUNTERCLOCKWISE direction.
- While in the arc command, press the right mouse button to select the following options for arcs:

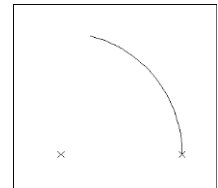


Arc Examples

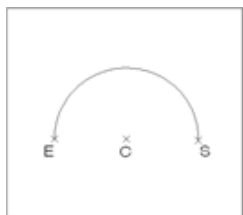
3 point arc



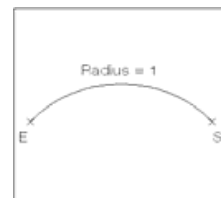
Start, center, chord length



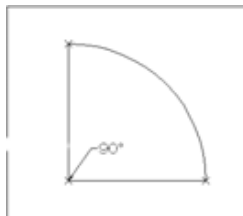
Start, center, end



Start, end, radius



Start, center, included angle



Start, end, direction

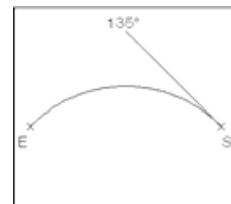


Fig 9.7

9.8.4. Rectangle

1. **Choose** Draw Rectangle.
or
2. **Click the** Rectangle icon. 
- or
3. **Type** Rectangle at the command prompt Command:
RECTANG Chamfer/Elevation/Fillet/Thickness/Width/
<First corner>:
4. **Pick** First corner.
5. **Pick** Other corner or type coordinates (i.e. @ 4, 2).

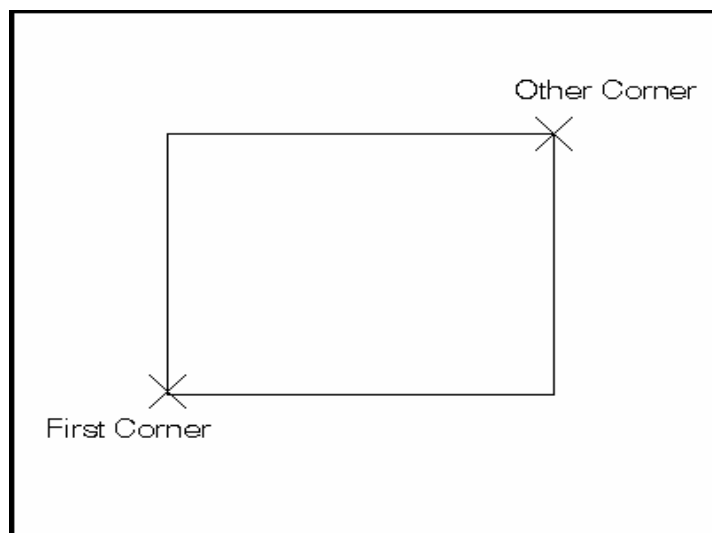


Fig 9.8

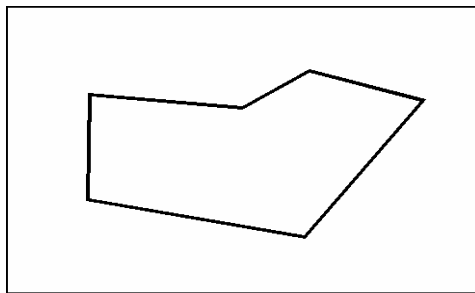
9.9. EDIT and MODIFY Commands

9.9.1 Editing Poly lines

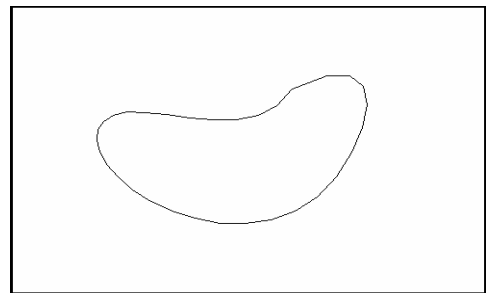
1. **Choose** *Modify, Polyline.*
or
2. **Pick** The Pedit icon from the Modify II toolbar. 
3. **Type** PEDIT at the command prompt
Command: **PEDIT**
4. **Pick** Pick a polyline to edit
Select Polyline:(**pick**)
5. **Type** One of the following options : Close / Join / Width / Edit vertex / FitCurve / Spline / Curve / Decurve / Undo / exit

9.9.2. PEDIT options

- Close** Closes open polyline segments
- Join** Connects polylines, lines, and arcs to existing polylines.
- Width** Changes the width for all polyline segments.
- Fitcurve** Creates curved arc segments around p line vertices at the direction you specify.
- Spline Curve** Creates a curve through control points on a polyline.
- Decurve** Straightens curved segments.
- Edit Vertex** Displays the following Edit Vertex Options:



Polyline width change

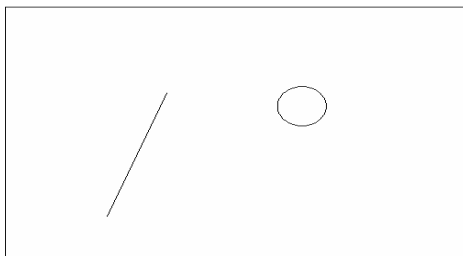


Splined Polyline

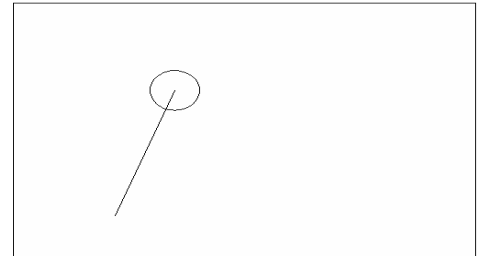
Fig 9.9.

9.9.3 Move Command

1. **Choose** Modify, Move.
or
2. **Click** the Move icon. 
- or
3. **Type** MOVE at the command prompt
Command : **MOVE or M**
4. **Pick** Objects to move
Select objects : **(select)**
5. **Pick** A point to move from
Base point or displacement : **(pick point)**
6. **Pick** A point to move to
Second point of displacement : **(pick point)**



Circle before move



Circle after move

Fig 9.10

TIP : To move an object a specified distance, type a distance at the second point of displacement prompt : **@1<0**

9.9.3. Copy Command

1. **Choose** Modify, Copy.
or
2. **Click** the Copy icon. 
- or
3. **Type** COPY at the command prompt.
Command : **COPY or CP**
4. **Pick** Objects to copy.
Select objects : **(select)**
5. **Pick** A point to move from.
Base point or displacement/Multiple: **(pick point)**.
6. **Pick** A point to copy to Second point of displacement: **(pick point)**

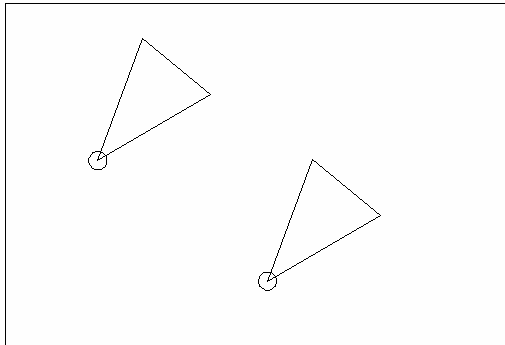
or

7. Type

A point to copy to.

Second point of displacement : @ 1<0

Duplicate objects copied



Multiple objects copied

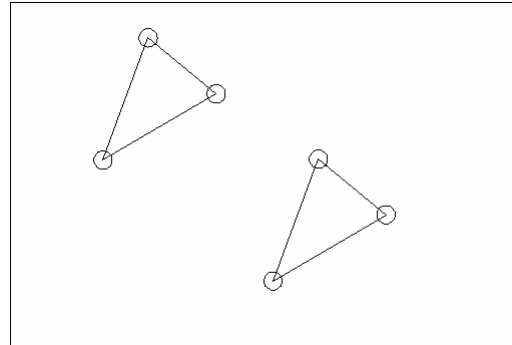


Fig 9.11

TIP : To copy many objects in the same copy command, type M for Multiple at the “Base point or displacement / Multiple” option.

9.9.5. Offset Command

Offset Distance

To offset a specified distance :

1. Choose Modify, Offset.

or

2. Choose the Offset icon. 

or

3. Type OFFSET at the command prompt.

Command : **OFFSET or O**

4. Type the distance to offset.

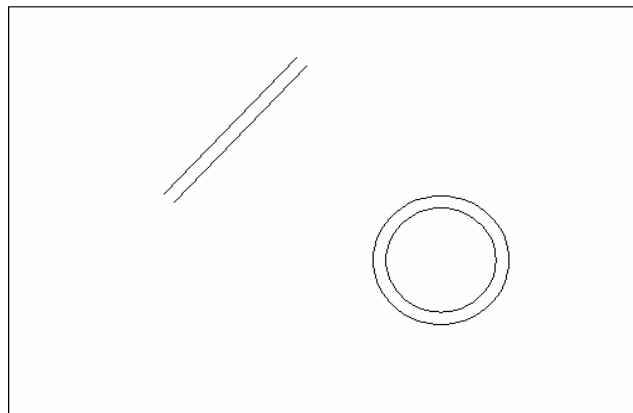
Offset distance or <Through point> : (number)

5. Pick the object to offset.

Select object to offset : (Select object)

6. Pick A side to offset object to.

7. **Pic** Side to offset : (pick side)
 Another object to offset
 Select object to offset : (pick side)
 or
8. **Press** Enter to end the command.



Offsetting objects by specifying a distance

Fig 9.12

1.9.6. Explode Command

1. **Choose** *Modify, Explode.*
 or
2. **Pick** the Explode icon. 
3. **Type** EXPLODE at the command prompt.
 Command : **EXPLODE**
 or
4. **Pick** The object to explode. Select objects : **(pick)**

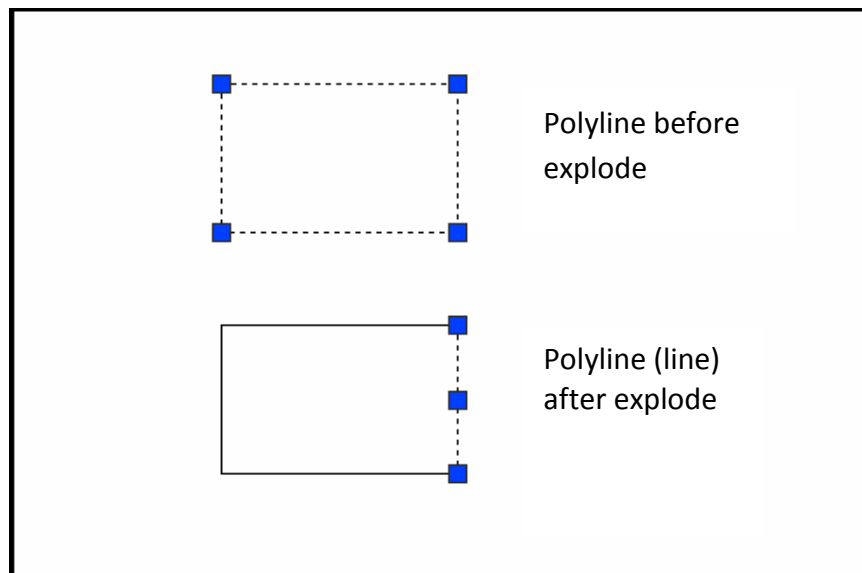


Fig 9.13

1.9.7. EXTEND

1. **Choose** Modify,Extend.

or

2. **Click** the Extend icon.



or

3. **Type** EXTEND at the command prompt

Command: **EXTEND** Select boundary edge(s)...

4. **Pick** The BOUNDARY edge to extend to Select objects:(**select**)

5. **Press** ENTER to accept the boundary edge

Select objects: (**press enter**)

6. **Pick** The objects to extend

<Select object to extend> / Project / Edge / Undo: Select an object, enter an option, or press enter: (**select**)

7. **Press** ENTER when you are done choosing objects.

Line extended to arc. Arc is boundary edge.

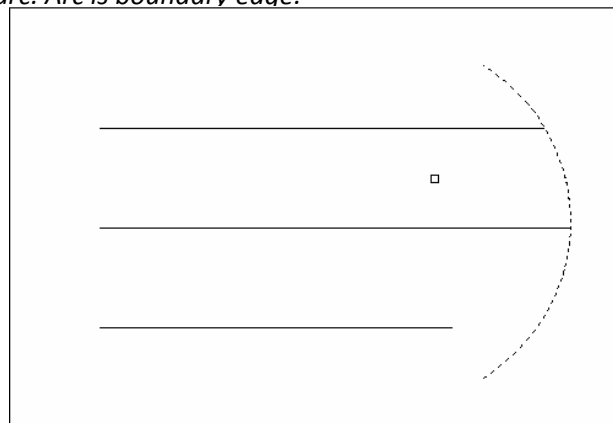


Fig 9.14

TIP :

- Use the object selection option FENCE to choose multiple objects

1.9.8. **Stretch**

1. **Choose** Modify,Stretch.
or
2. **Click** the Stretch icon. 
3. **Type** STRETCH at the command prompt.
Command: **STRETCH** Select objects to stretch by window...
4. **Type** C to choose CROSSING window
Select objects: **C**
5. **Pick** A first corner to stretch. First corner:(point)
6. **Pick** The opposite corner to window the objects to stretch.
Other corner: **(point)**

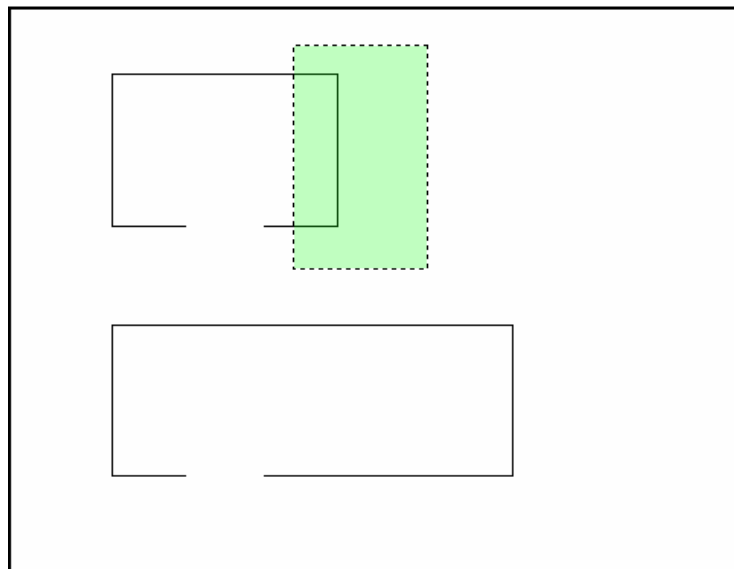


Fig 9.15

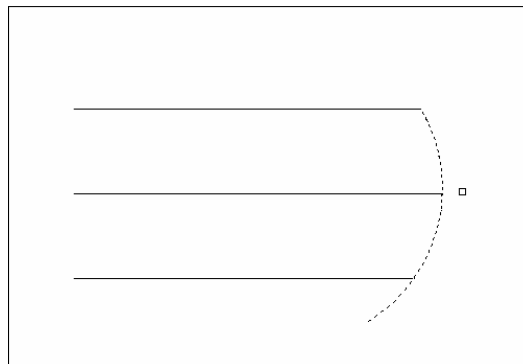
7. **Press** ENTER to accept objects to stretch.
8. **Pick** A base point to stretch from Base point : **(point)**
9. **Pick** A point to stretch to New point: **(point)**
or
10. **Type** A distance to stretch. Newpoint: **@1<0**

TIP : The Stretch command must use a CROSSING window or a CROSSING POLYGON window.

1.9.9. TRIM

The TRIM command allows you to trim objects in a drawing so they end precisely at a cutting edge defined by one or more other objects in the drawing.

1. **Choose** Modify, Trim.
or
2. **Click** the Trim icon. 
3. **Type** TRIM at the command prompt
Command: **TRIM**
Select cutting edge(s)...
4. **Pick** The CUTTING edge to extend to Select objects: (**select**)
5. **Press** ENTER to accept the cutting edge
Select objects: (**press enter**)
6. **Pick** Objects to trim
<Select object to trim> / Project / Edge / Undo :
Select an object, enter an option, or press enter
7. **Press** ENTER when you are done choosing objects
Select object to trim/Undo: (**press enter**)



*Lines Trimmed to an Arc
(Arc is cutting edge)*

Fig.9.16

TIP : Hold the SHIFT key to interactively extend instead of trim.

1.9.10. Break

1. **Choose** Modify,Break.
or
2. **Click** the Break icon.  or

3. **Type** BREAK at the command prompt. Command : **BREAK**

4. **Pick** Object to break.

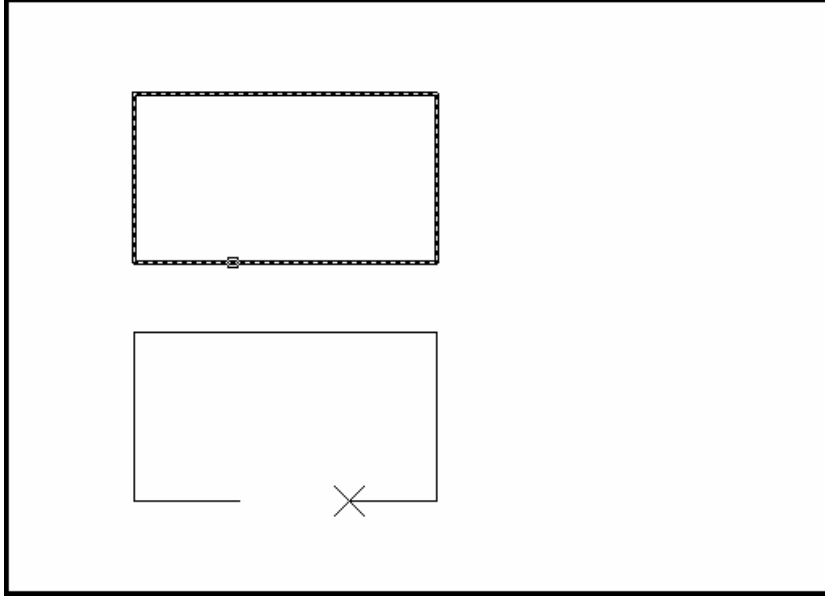


Fig 9.17

Select object : (**select one object**)

5. **Pick** A second break point. Enter second point: (**point**)

or

6. **Type** **F** to choose a different break point
Enter second point (or F for first point): (**F**)

1.9.11. MIRROR

1. **Choose** Modify, Mirror.

or

2. **Click** the Mirror icon.

or



3. **Type** MIRROR at the command prompt.
Command: **MIRROR**

4. **Pick** Objects to mirror.
Select objects: (**select**)

5. **Pick** First point of mirror line: (**point**)

6. **Pick** Second point: (**point**)

7. **Type** Yes to delete the original objects and No to keep them.

Delete old objects? **Y** or **N**

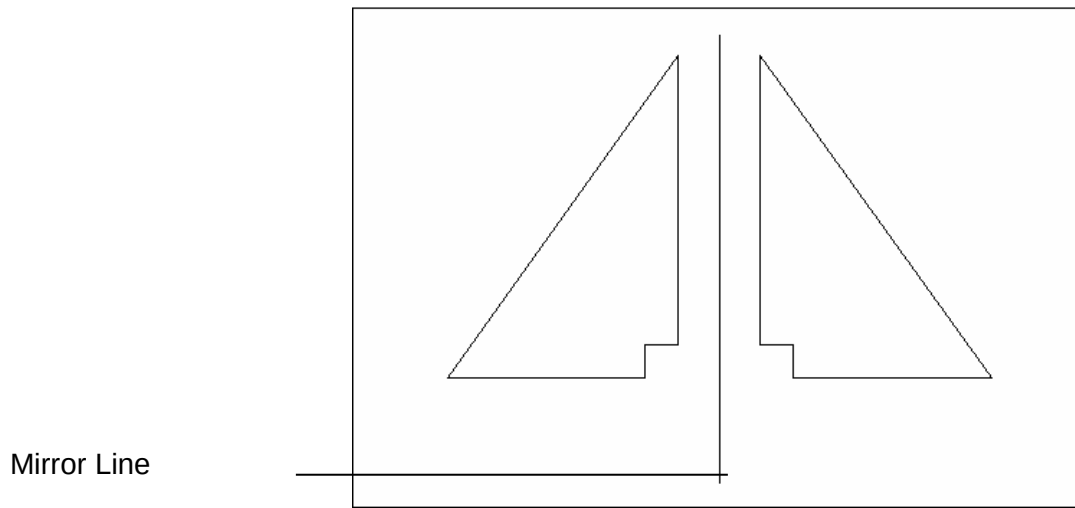


Fig 9.18

1.9.12. ROTATE

1. **Choose** Modify, Rotate.
or
2. **Click** the Modify icon. 
or
3. **Type** ROTATE at the command prompt
Command: **ROTATE**
4. **Pick** Objects to rotate: Select objects: (**select**)
5. **Pick** A pivot point to rotate around
Base point: (**point**)
6. **Type** A rotation angle<Rotation angle> / Reference : (**number**)
or
7. **Pick** A rotation angle<Rotation angle>/Reference : (**point**)

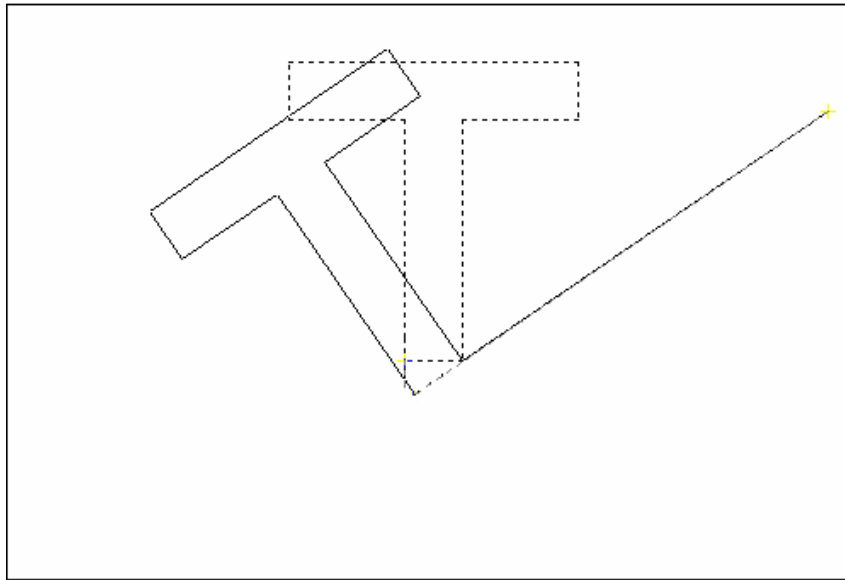


Fig 9.19

1.9.13. SCALE

1. **Choose** Modify, Scale.
or
2. **Click** the Scale icon. 
or
3. **Type** SCALE at the command prompt
Command : **SCALE**
Select objects : **(select objects)**
4. **Pick** A pivot point to scale about Base point : **(point)**
5. **Type** A rotation angle <Scale factor>/Reference : **(number)**
or
6. **Pick** A scale factor <Scale factor>/Reference : **(point)**
Scale factor / Reference: **(points)**

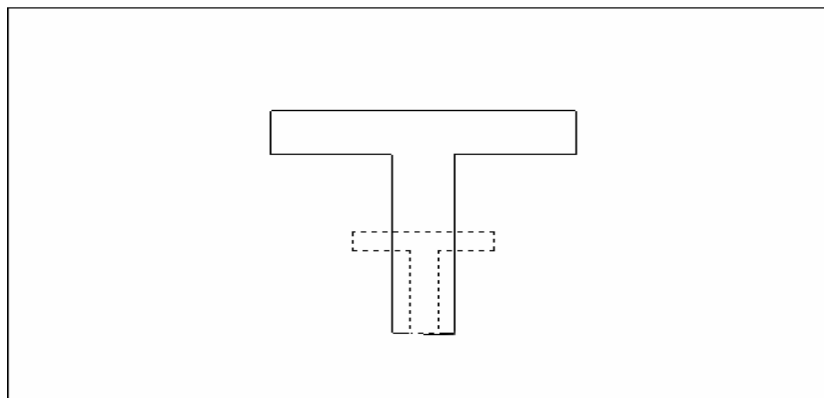


Fig 9.20

9.9.14 CREATING AND ARRAY OF OBJECTS

The array command in AutoCAD is used to make multiple copies of objects. Although you can use the copy command to duplicate objects, the array command is more flexible and precise. One advantage of using the array command is that it allows you to copy objects in a defined angle and exact number of copies. Therefore, you can create array in various pattern. For example, you can show multiple objects in a row, column, or irregular pattern such as a spiral. Let's look at a few examples below:

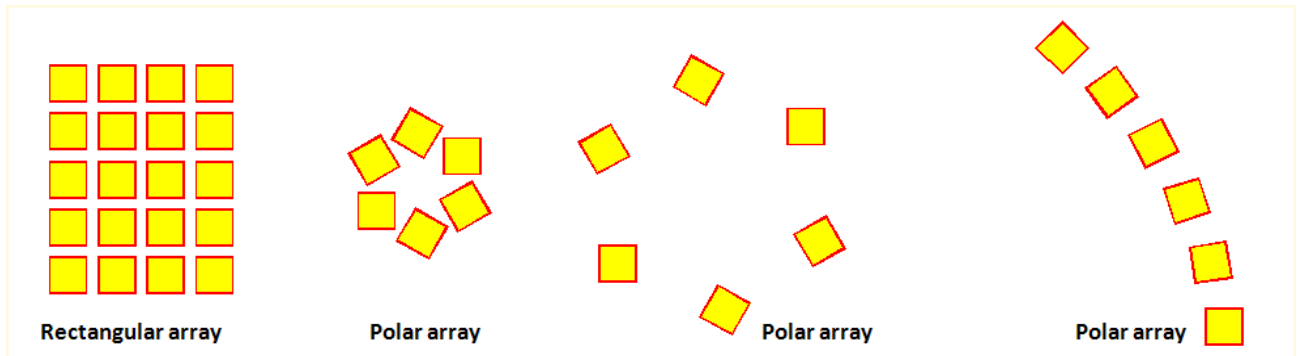


Fig 9.21

To create an array of objects follow the steps below.

9.9.14.1 RECTANGULAR ARRAY

1. Type **Array** in the command line or select  from the modify toolbar.
 2. Select the **object** you would like to array.
 3. Input the **number of rows**. (negative number for downward array)
 4. Input the **number of columns**. (negative number will point array to the left)
 5. Pick or input the **distance** for the Row offset.
 6. Pick or input the **distance** for the Column offset.
 7. Enter the **Angle** for the array. (Use the default 0 degree).
 8. Select the **Preview** button to see the sample array before you hit the **Ok** button. You can accept the array or modify it. (Optional step).
- See the figure below for visual step by step instructions.

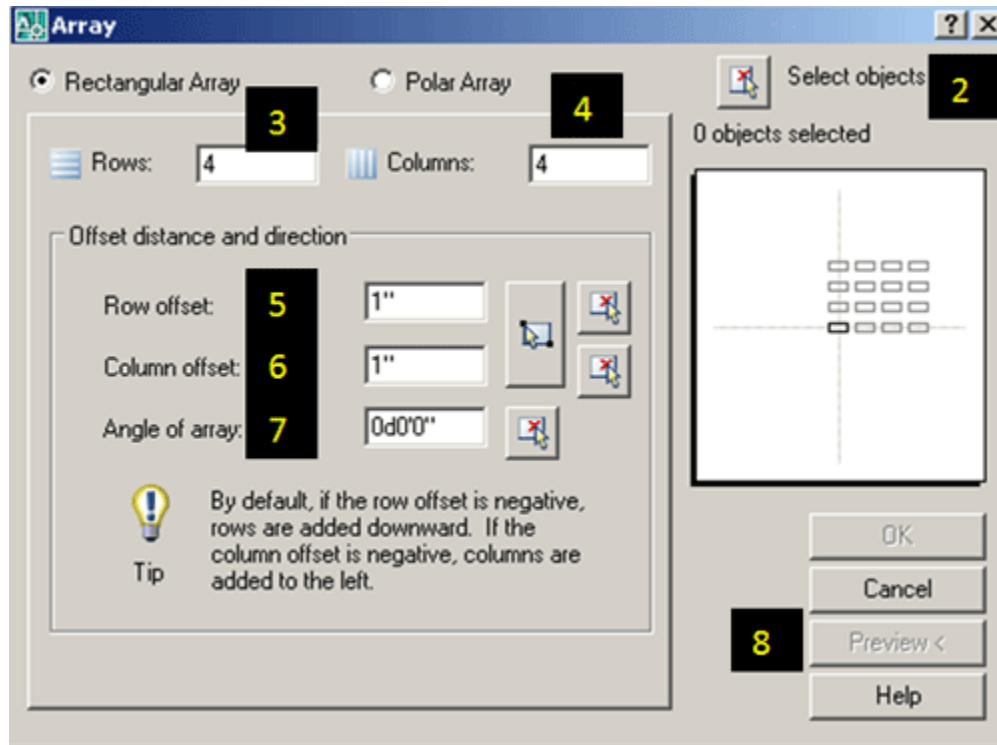


Fig 9.22

9.9.14.2 POLAR ARRAY



1. Type **Array** in the command line or select  from the modify toolbar.
 2. Select the **object** you would like to array.
 3. Enter or select the **center point** of rotation for the object.
 4. Select a **method of array**. (3 methods to choose from see terms definitions below).
 5. Enter the **number of items** to array. (Methods 1 and 2).
 6. Enter the **array angle**. (Methods 1 and 3).
 7. Enter the **angle** between the objects. (Methods 2 and 3).
 8. Make sure to check "Rotate items as copied" if you would like to copy the objects as selected.
 9. For **Object base point** use the default selected. (Optional step).
 10. Select the **Preview** button to see the sample array before you hit the **Ok** button. You can accept the array or modify it. (Optional step).
- See the figure below for visual step by step instructions.

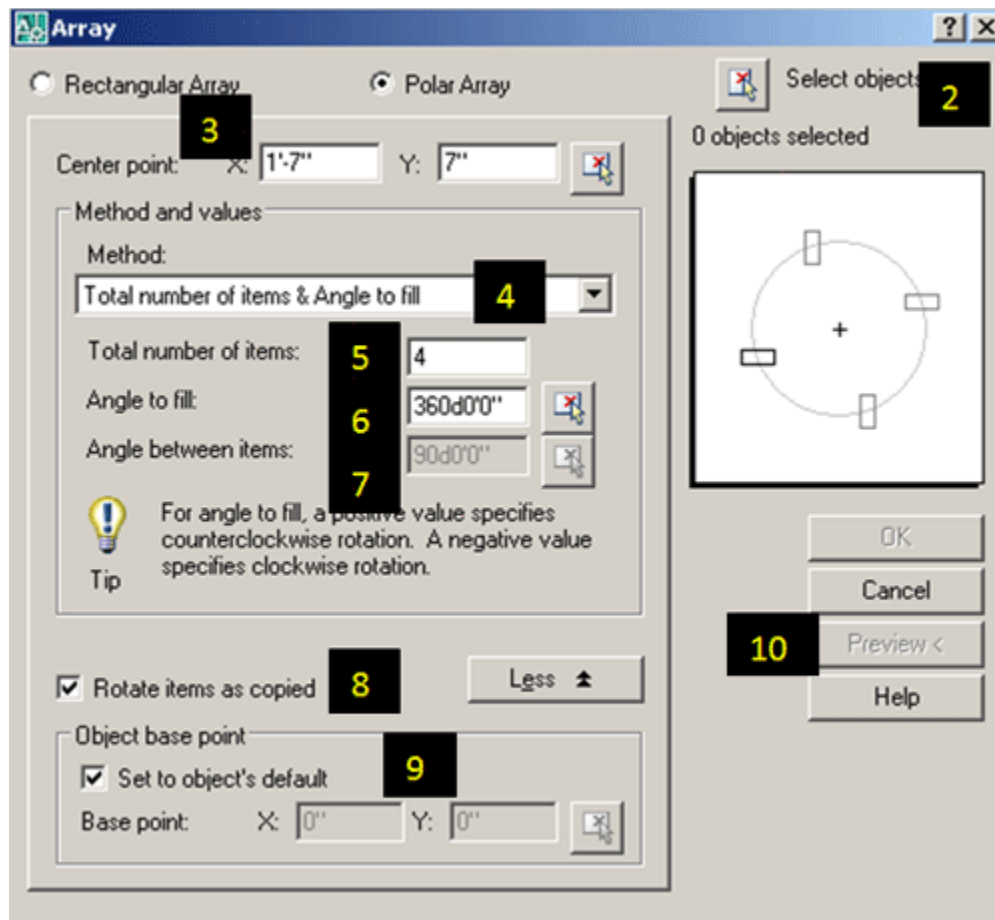


Fig 9.23

9.9.15 CHAMFER

The chamfer command in AutoCAD is used to create slanted edges.

We are required to select the two adjacent lines to create chamfer between them as shown in below image

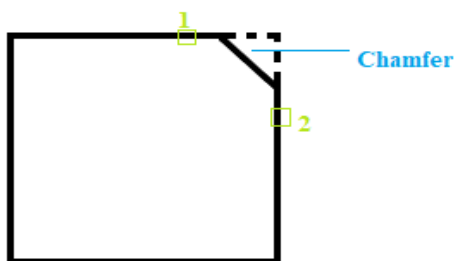


Fig 9.24

Here, 1 and 2 are the selected lines.

We can create the chamfer by specifying either the chamfer **distance** or **angle**.

Let's discuss in detail with two examples. Consider the below image:

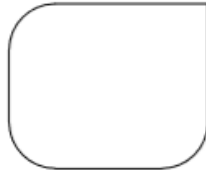


Fig 9.25

Example 1 : To create chamfer by specifying the distance:

The steps are listed below:

1. Select **Chamfer icon** from the drop-down list of Fillet, as shown below: Or

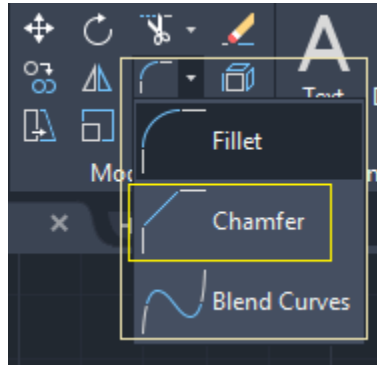


Fig 9.26

Type **CHA** or **chamfer** on the command line or command prompt and press **Enter**.

2. Type **D** or **Distance** on the command line.
3. Press **Enter**.
4. Specify **first distance** value and press **Enter**.
5. Specify **second distance** value and press **Enter**.

Here, we have specified the first and second distance value as **2** and **3**.

6. Click on the **first line** and the **second line**, as shown in the below image:

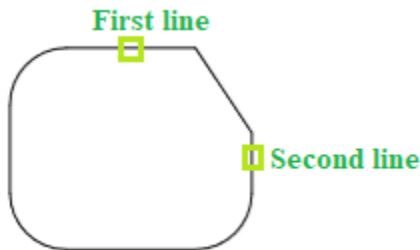


Fig 9.27

The chamfer will be created. We can verify the first and second distance values, as shown below:

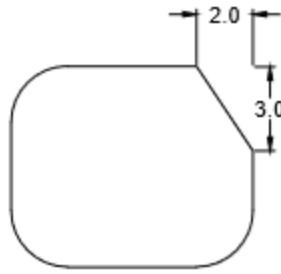


Fig 9.28

We can either specify the end points of a chamfer on the lines.

Example 2 :

To create chamfer by specifying the angle.

The steps are listed below:

1. Select **Chamfer icon** from the drop-down list of Fillet, as shown below:
Or
Type **CHA** or **chamfer** on the command line or command prompt and press **Enter**.
2. Type **A** or **Angle** on the command line.
3. Press **Enter**.
4. Specify the length of Chamfer on the first line and press **Enter**. Here, we have specified the length = 5.
5. Specify **Angle value** and press **Enter**.
6. Click on the **first line** and the **second line**, as shown in the below image:

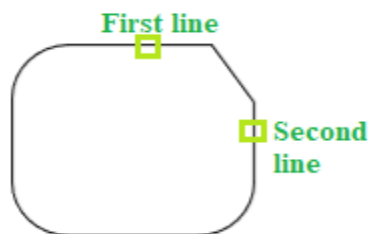


Fig 9.29

The chamfer will be created. We can verify the specified chamfer length, as shown below :

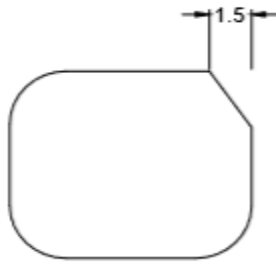


Fig 9.30

9.9.15.2 MULTIPLE CHAMFER

The **Multiple chamfer** command is used to apply chamfer multiple times with the same specified distance or angle. We are not required to use the chamfer command again and again.

To implement it, follow the steps:

1. Type **Chamfer** on the command line.
2. Press **Enter**.
3. Type **M** or **multiple** and press **Enter**.
4. Follow the same steps for the **distance** or **angle**

9.9.16 FILLET IN AUTOCAD

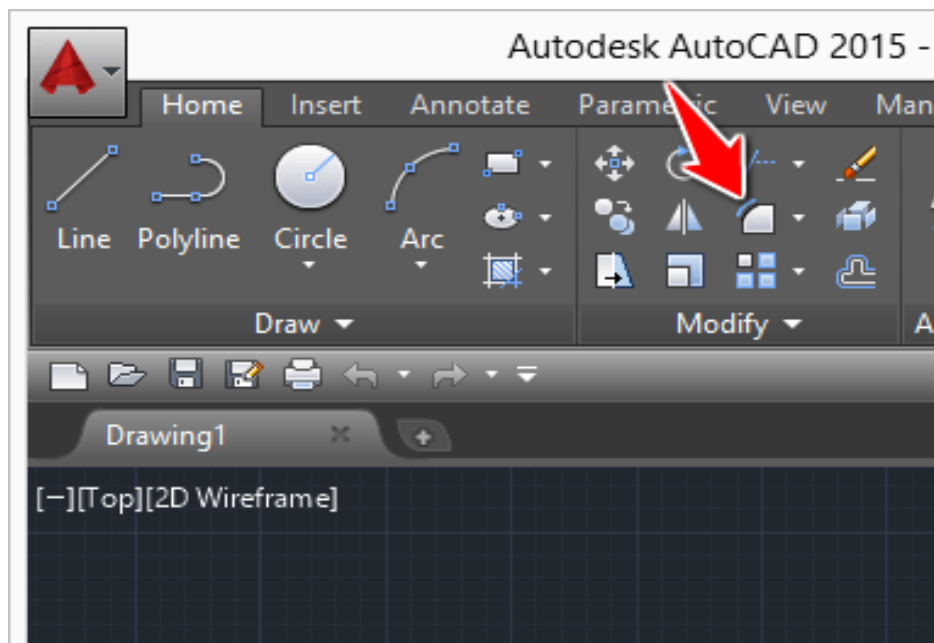


Fig 9.31

To use the Fillet command

1. Click on the fillet command icon
2. Type **R** and Press Enter

3. Specify the fillet Radius and Press Enter
4. Select the first line
5. Select the second line

The image below shows an example of Fillet with R=20.



Fig 9.32

9.10. Text Command

9.10.1. Text

Creates a single-line text object

1. **Type** TEXT at the command prompt
Command: **TEXT** or
2. **Pick** the Single Line Text icon from the Text Toolbar. 
3. **Pick** A start point
Justify/Style/<Start Point>: (**point**)
or
4. **Type** J to change the justification or S to change the text style.
5. **Type** A text height
Height <default>: (**type value or pick two points**)
6. **Type** A rotation angle
Rotation angle <default>: (**angle or point**)
7. **Type** A text string
Text: (**type text string**)
8. **Press** enter to exit the Text: prompt.

9.10.2. DTEXT (Dynamic Text)

Creates a single-line text object, showing the text dynamically on the screen as it is entered.

1. **Choose** Draw, Text, Single Line Text.

or

2. **Type** DTEXT at the command prompt

Command : **DTEXT**

Follow the steps 3-8 from above

9.11 SOLVED PROBLEMS

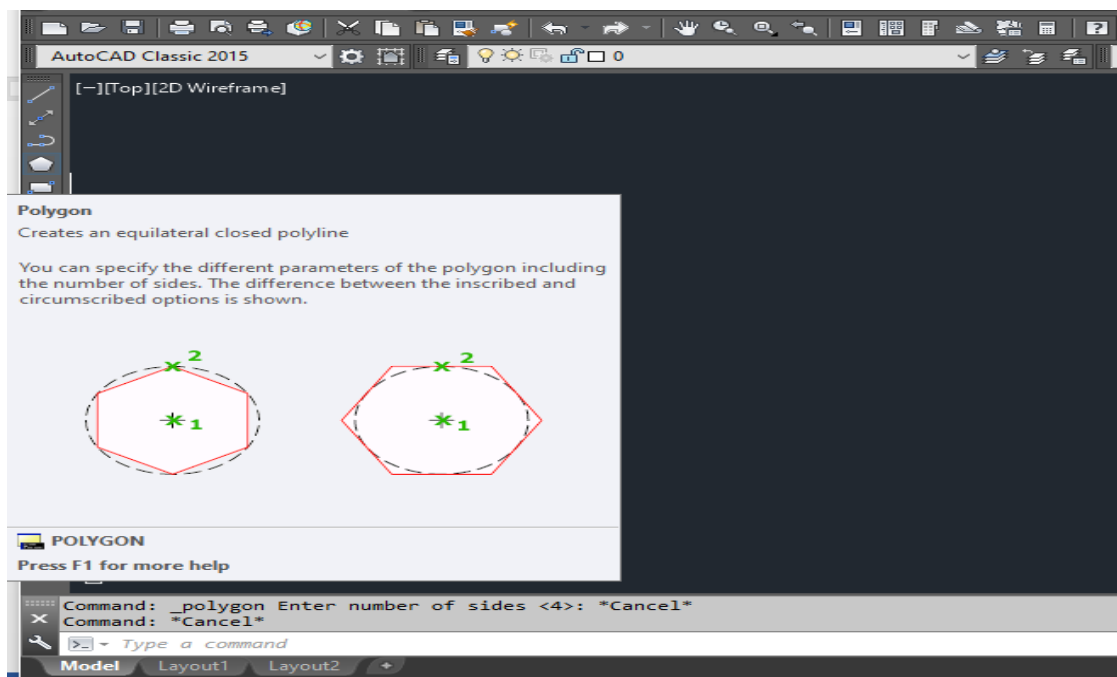
Q.No. 1. Draw the projections of octagonal prism of side of base 25mm and height 50mm resting with its base on H.P. such that one of its rectangular faces is perpendicular to V.P.

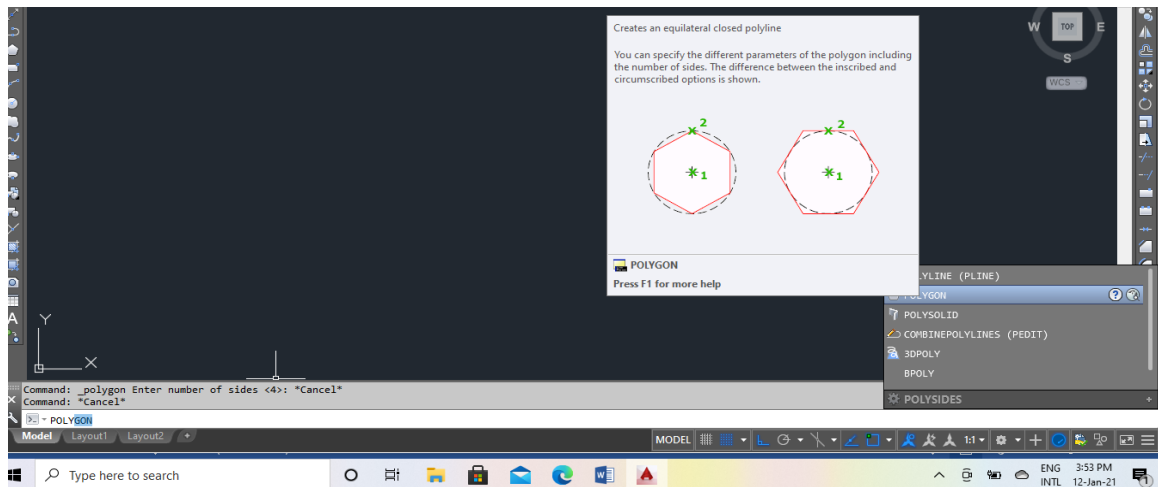
PLAN

1. Select polygon in ribbon bar

or

Write **pol** in command window and press Enter



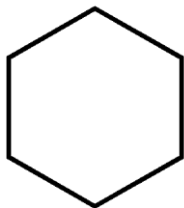


2. POLYGON ENTER NUMBER OF SIDES <4>: 8
3. SPECIFY CENTRE OF POLYGON OR [EDGE] : E SPECIFY FIRST END POINT OF EDGE:
SPECIFY SECOND END POINT OF EDGE:25

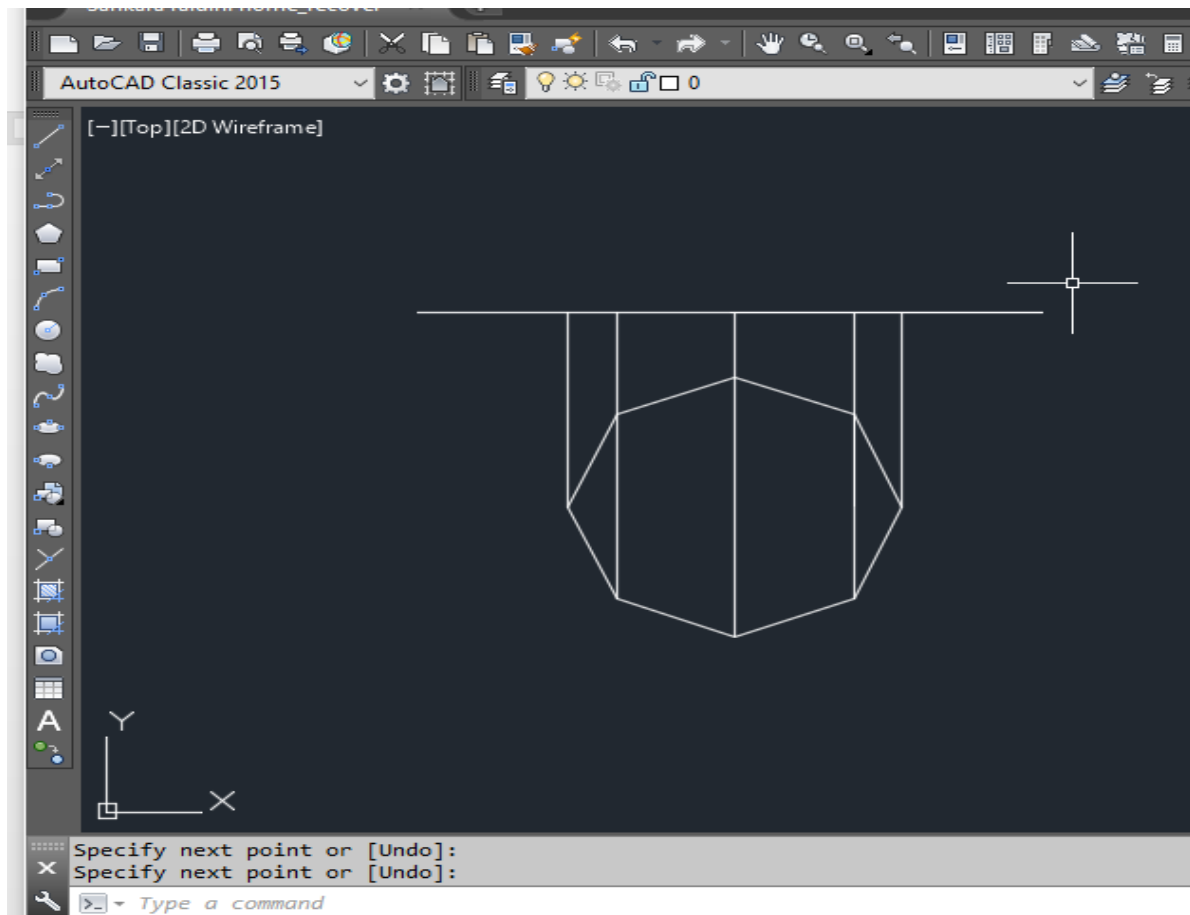
Fig 9.33

ELEVATION

1. Create a horizontal line.



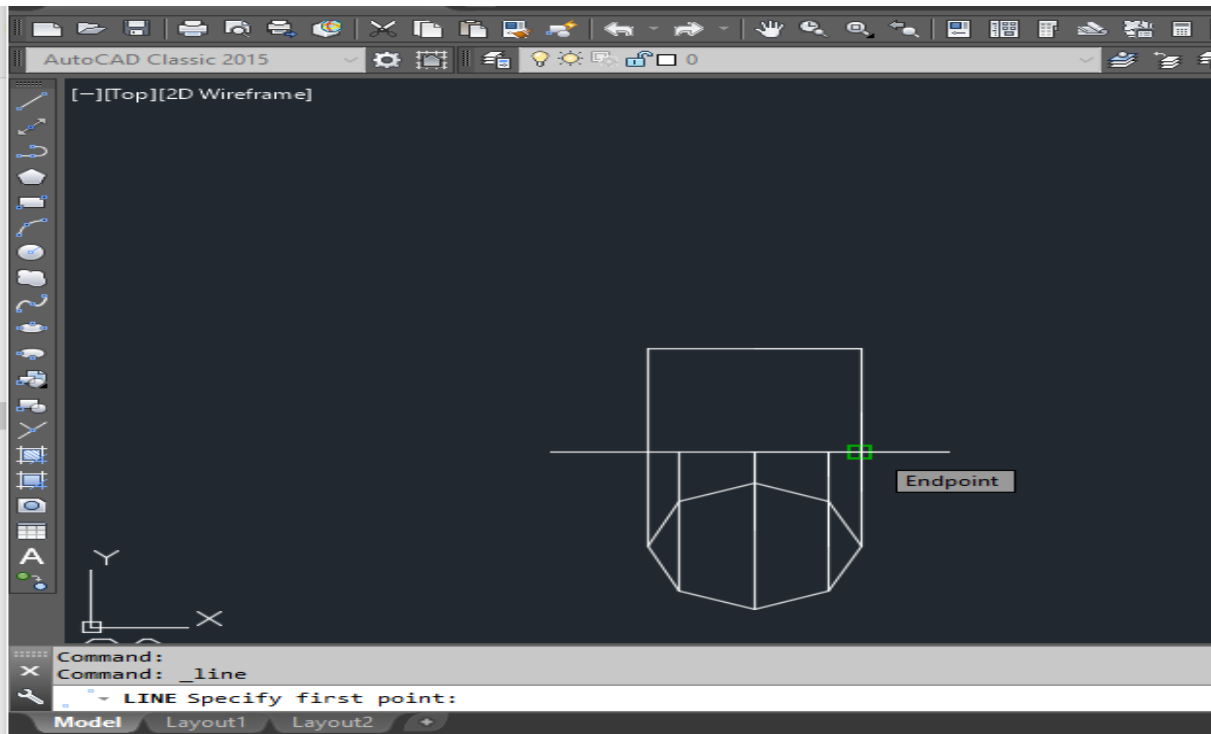
2. Then use Line command to draw perpendicular to horizontal line.



3. COMMAND: PLINE SPECIFY STARTPOINT:

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.

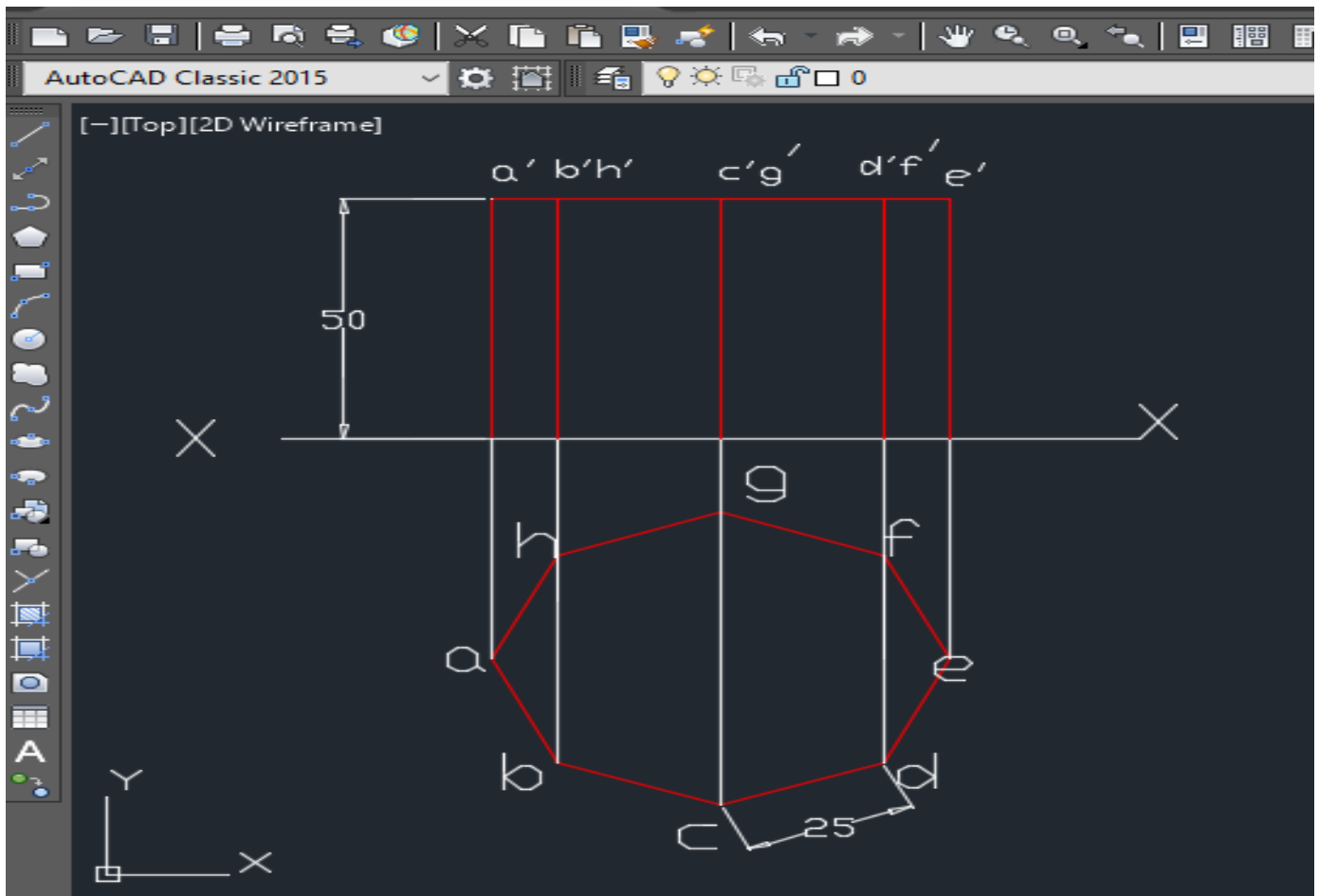
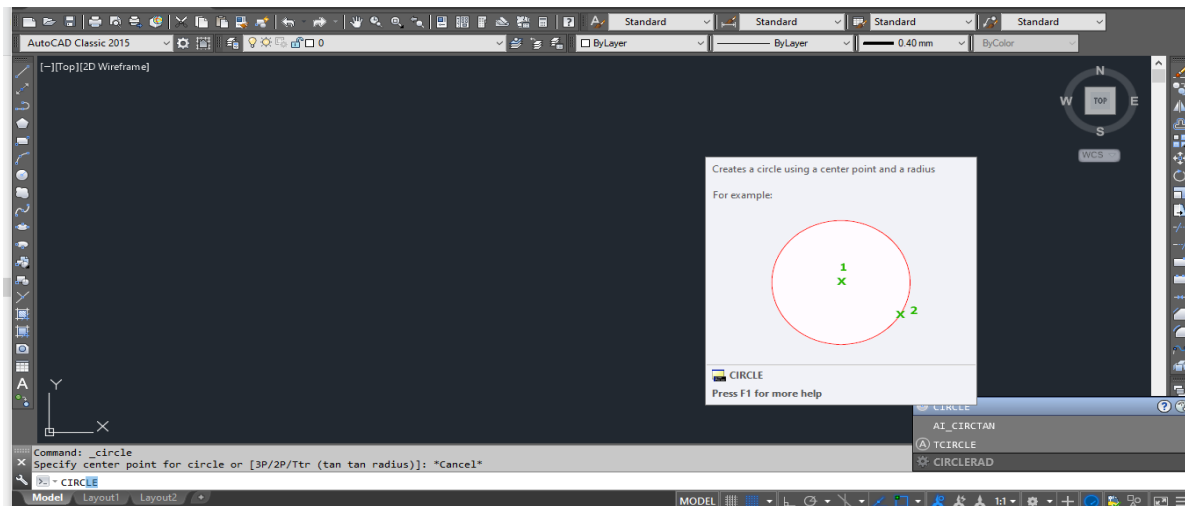


Fig 9.34

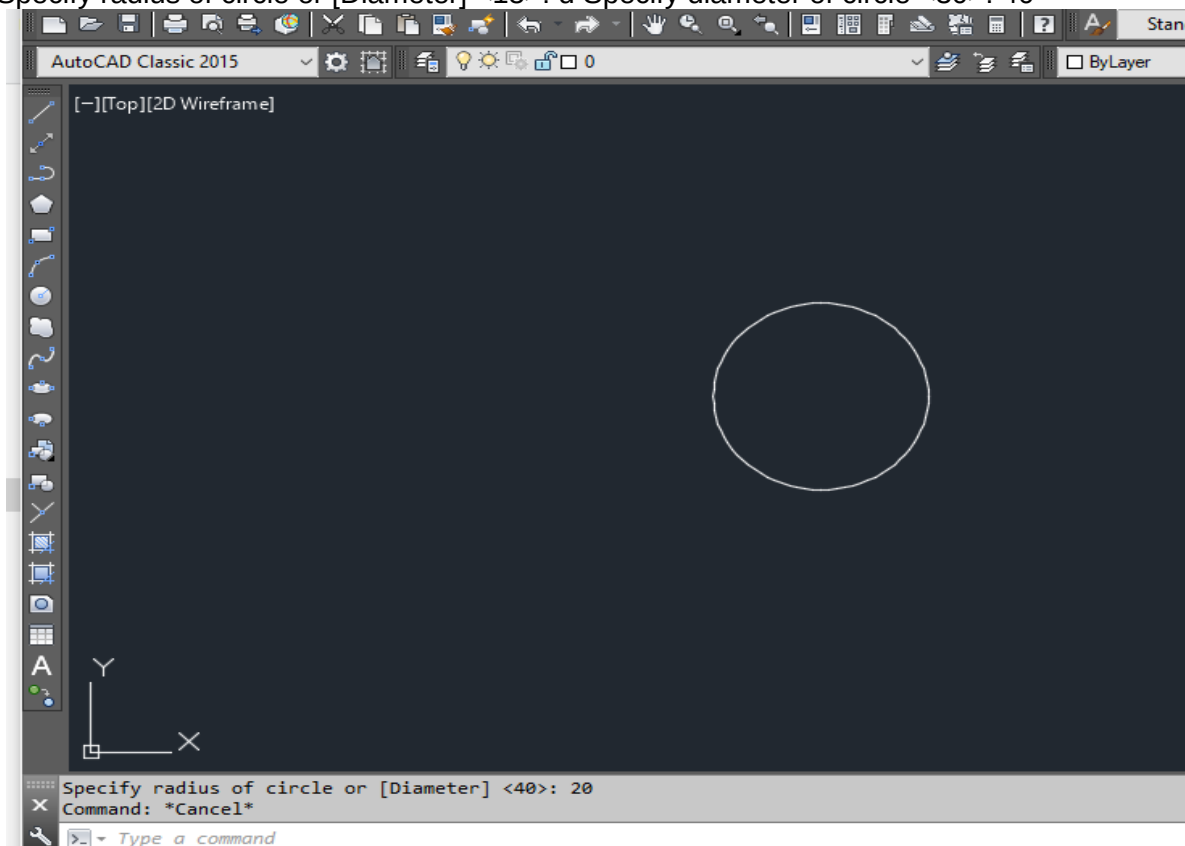
Q. No. 2. Draw the projection of a cylinder of base 40mm diameter and axis 60mm long resting with its base on H.P. and axis 25 mm in front of V.P.

PLAN

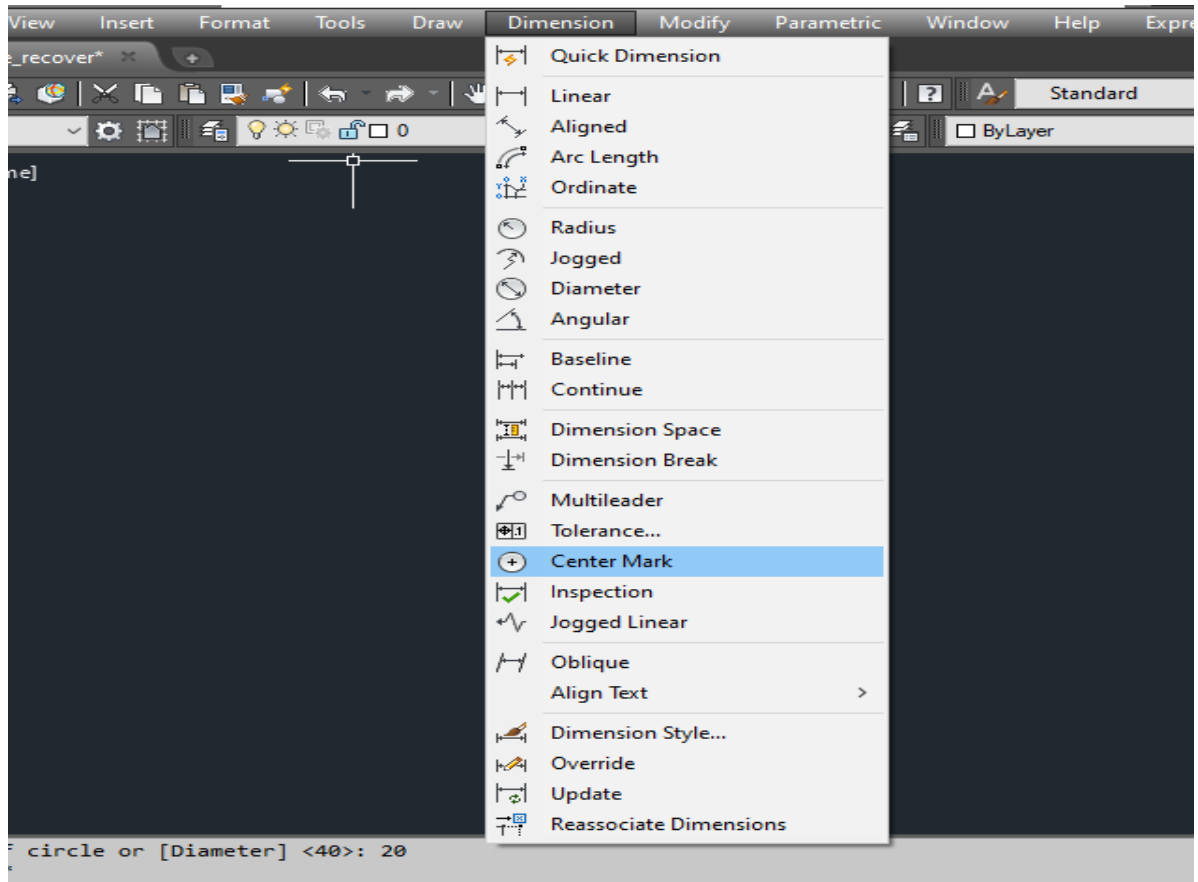
4. Command: C or CIRCLE



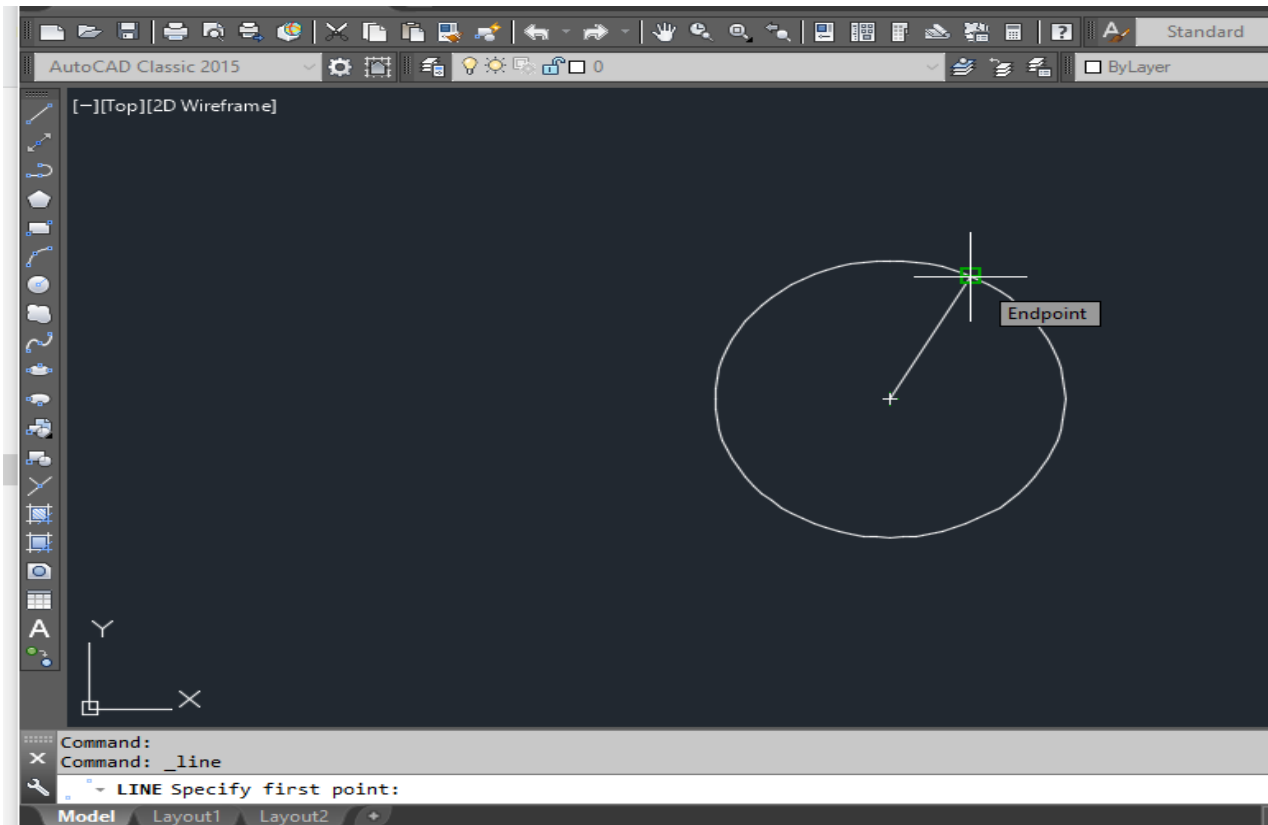
5. Specify center point for circle or [3P/2P/Ttr (tan tan radius)] :
Specify radius of circle or [Diameter] <15>: d Specify diameter of circle <30>: 40



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



7. Command: I
LINE Specify first point:
Specify next point or [Undo]: @15<40& extend the line



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

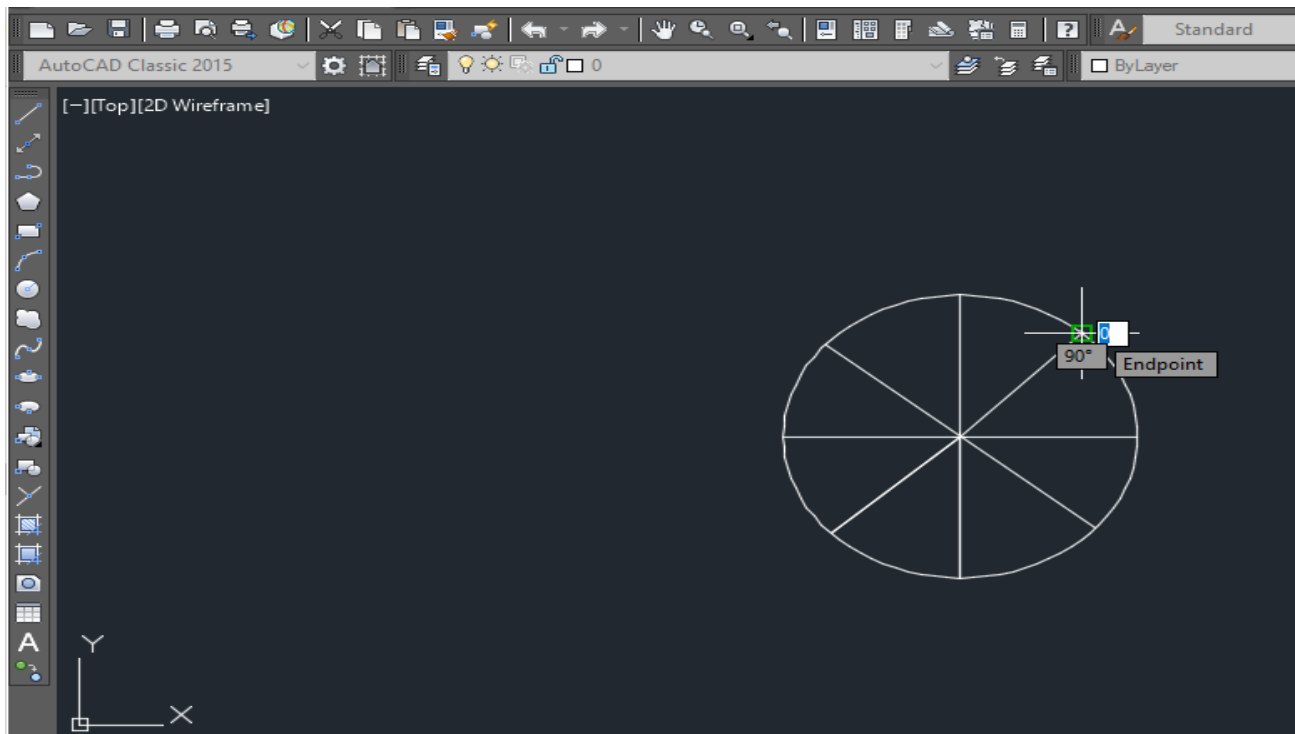
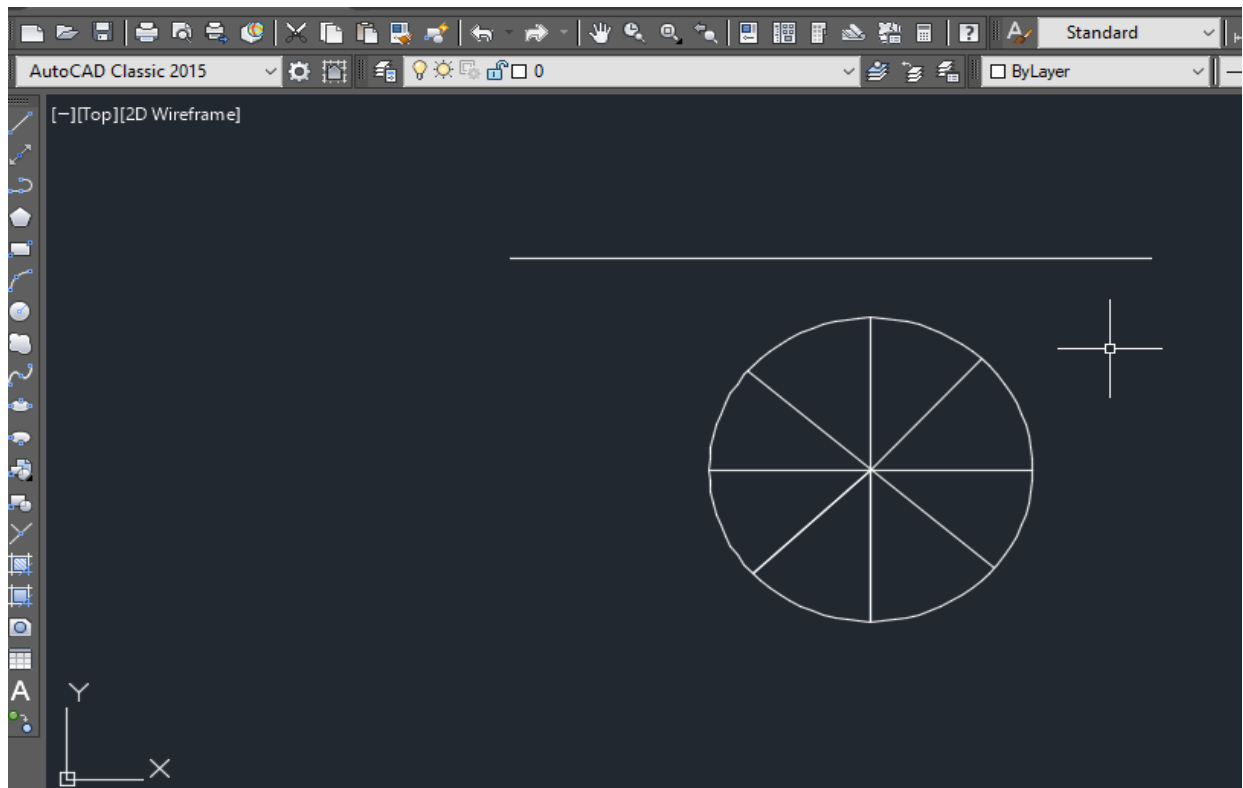


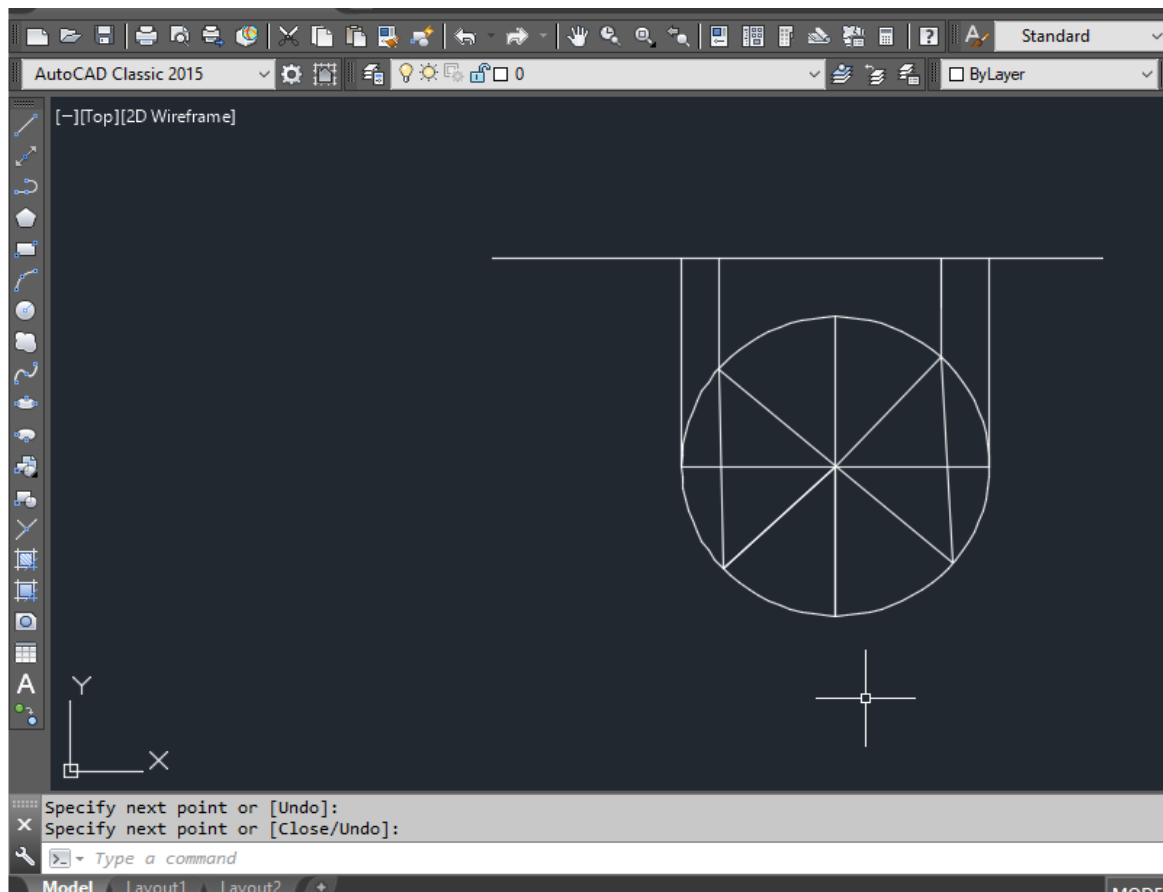
Fig 9.35

ELEVATION

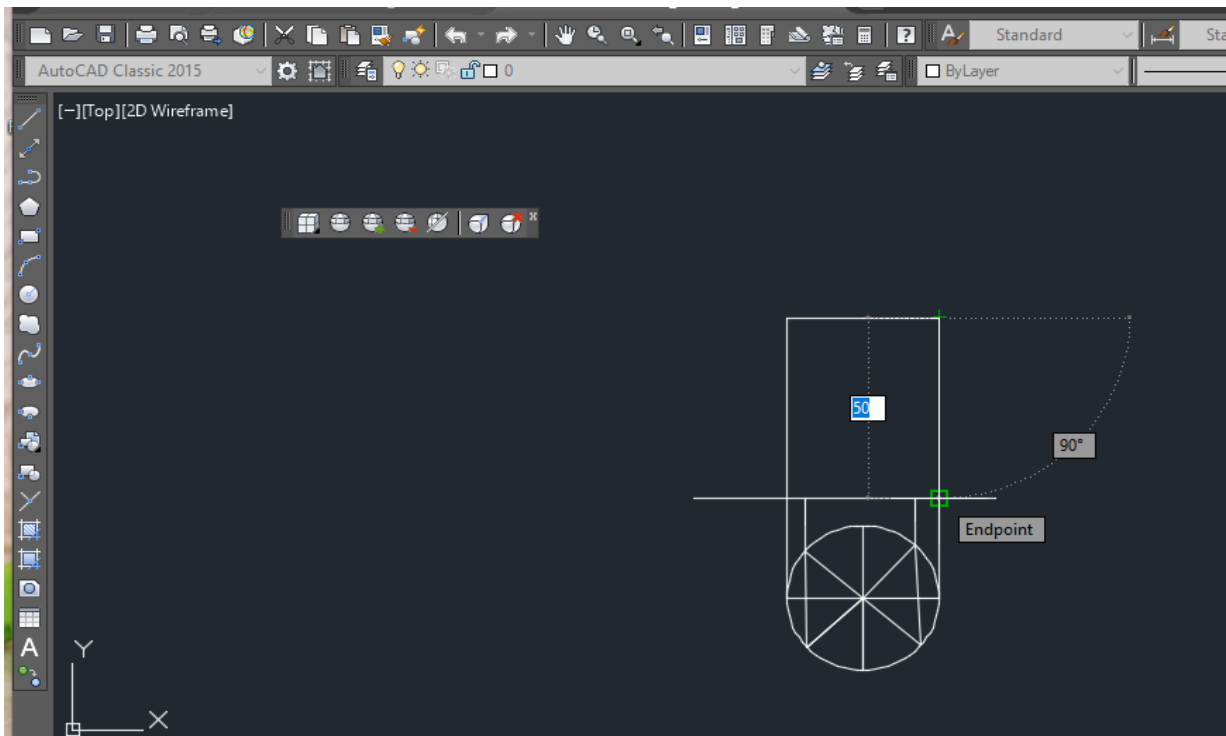
5. Create a line of horizontal



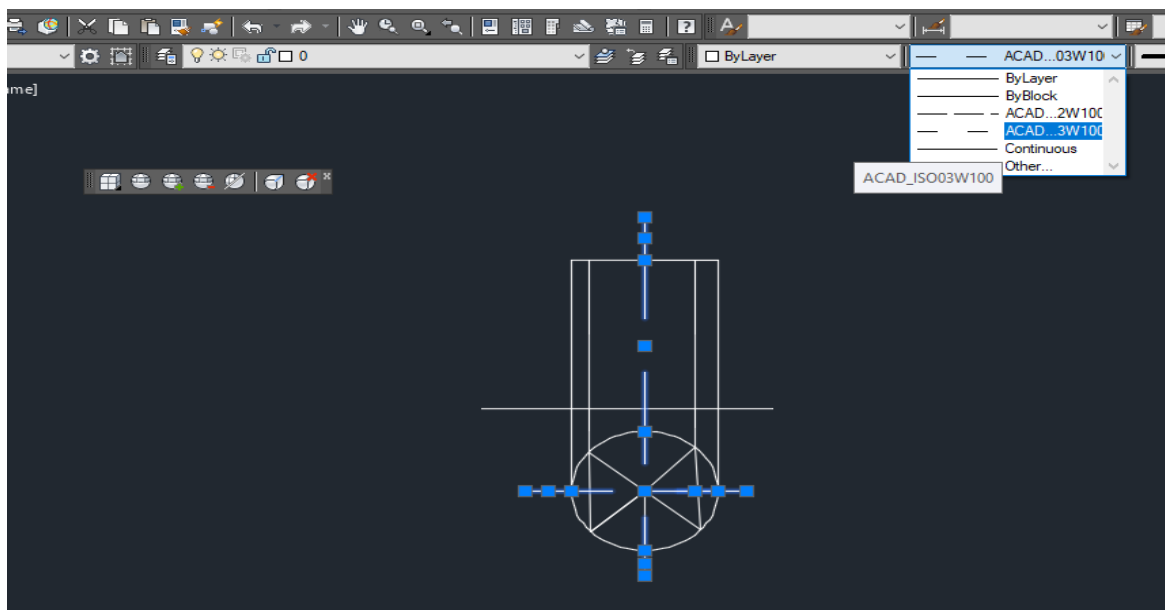
6. Then use command L and press ENTER.
7. Draw perpendiculars from the points on circle to horizontal line.



8. COMMAND : PLINE SPECIFY STARTPOINT:
CURRENT LINE-WIDTH IS 1
SPECIFY NEXT POINT OR [ARC/HALFWIDTH/LENGTH/UNDO/WIDTH]: 60



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.

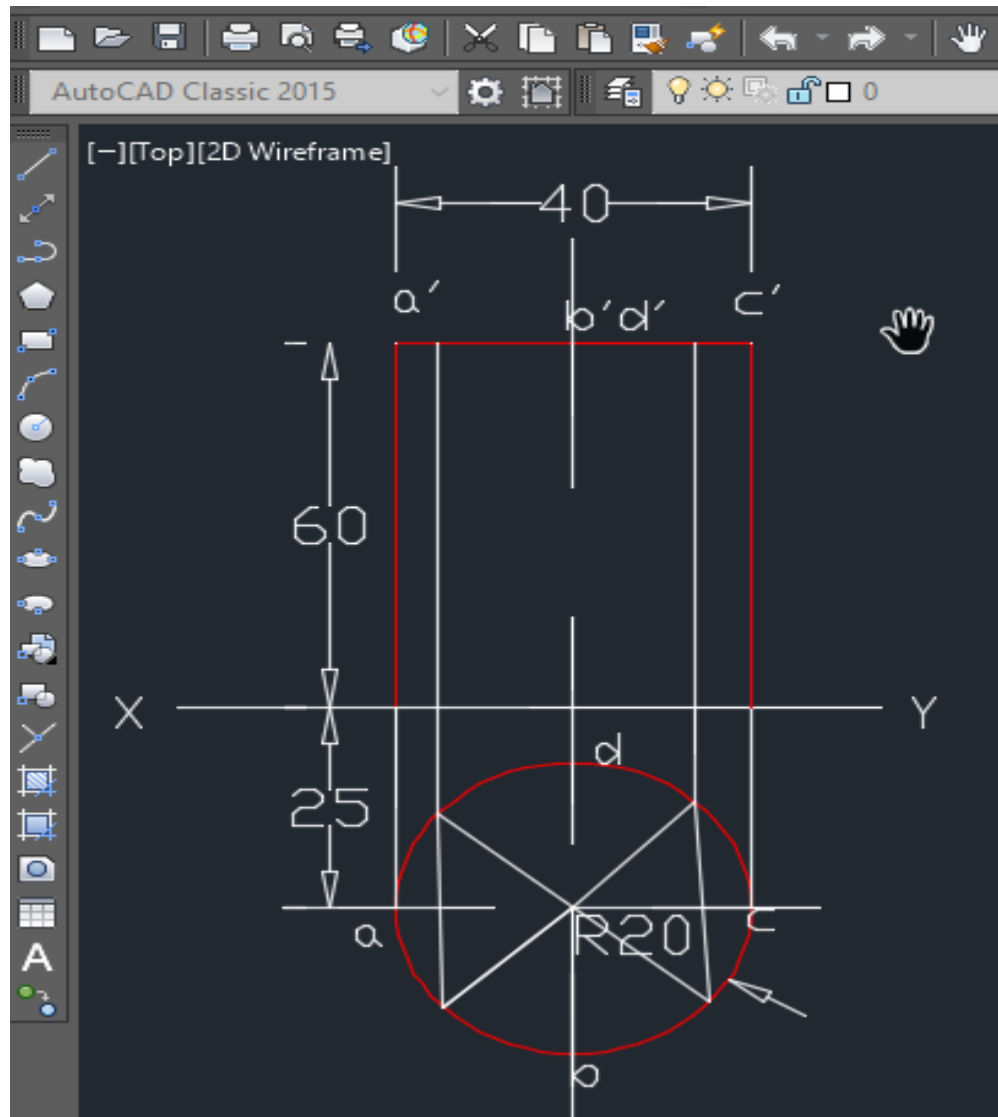
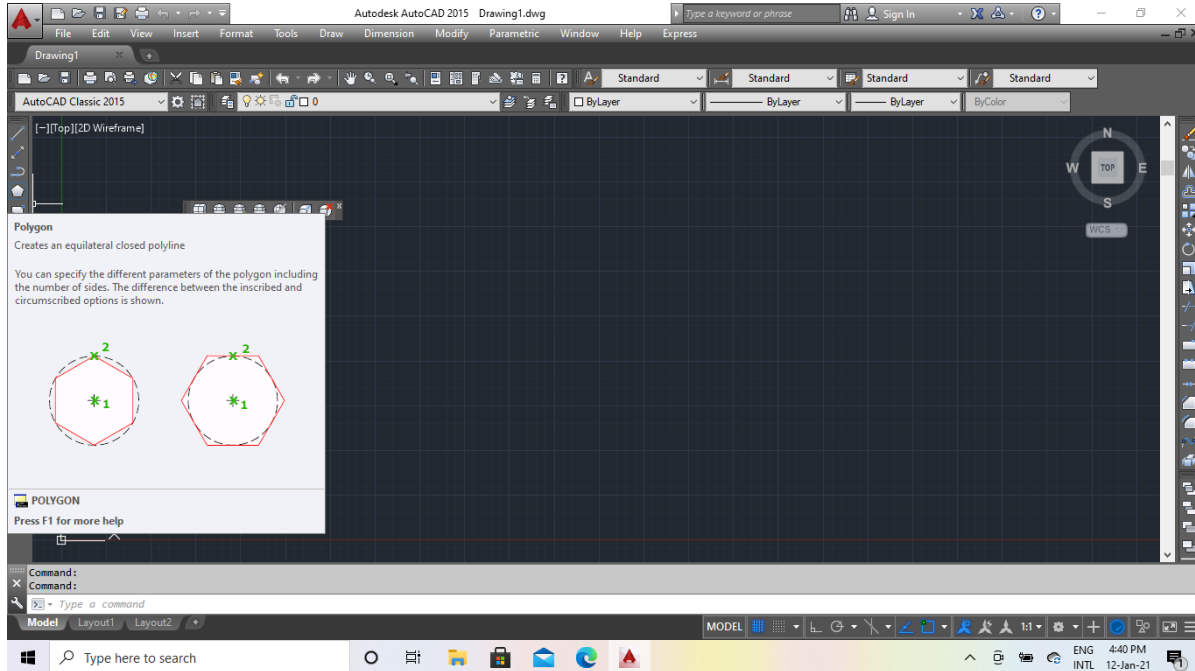


Fig 9.36

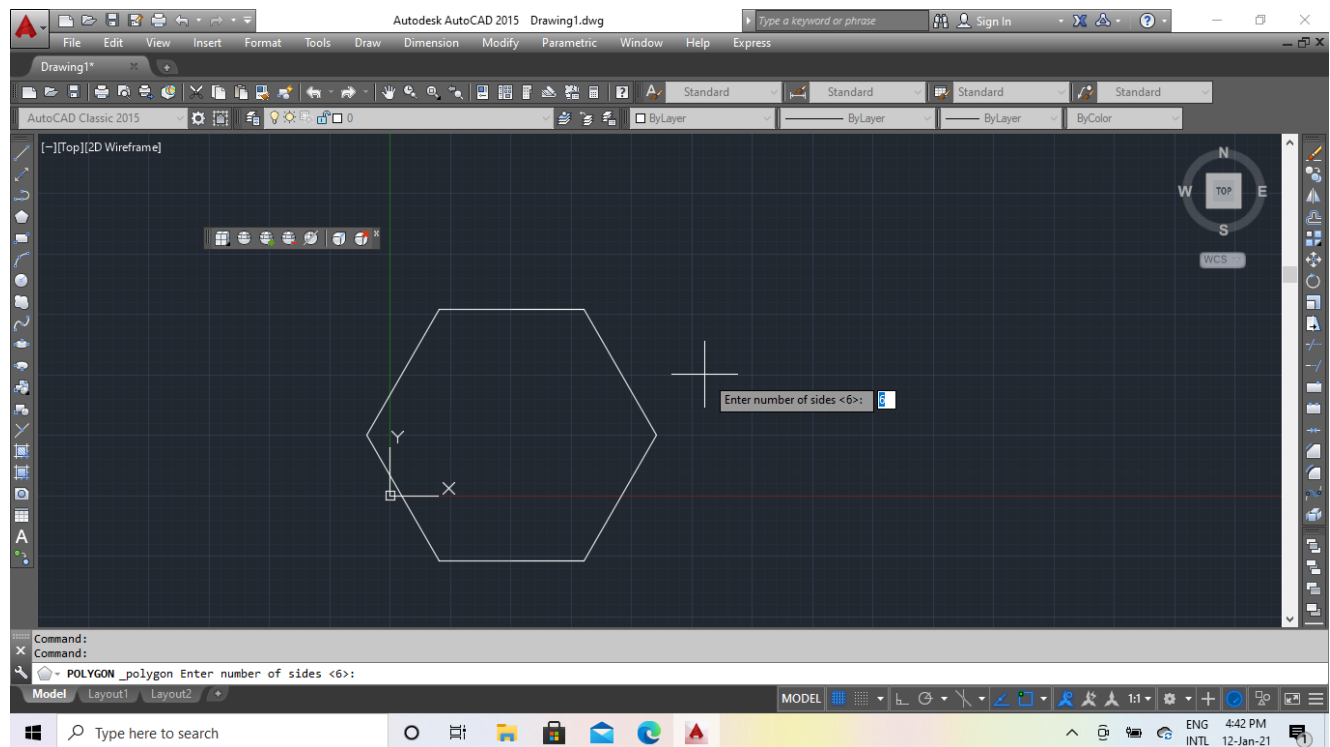
Q. No. 3. Draw the projections of pentagonal pyramid side of base 30mm and height 60mm resting with its base on H. P. such that one of the edge of the base is perpendicular to V.P.

PLAN

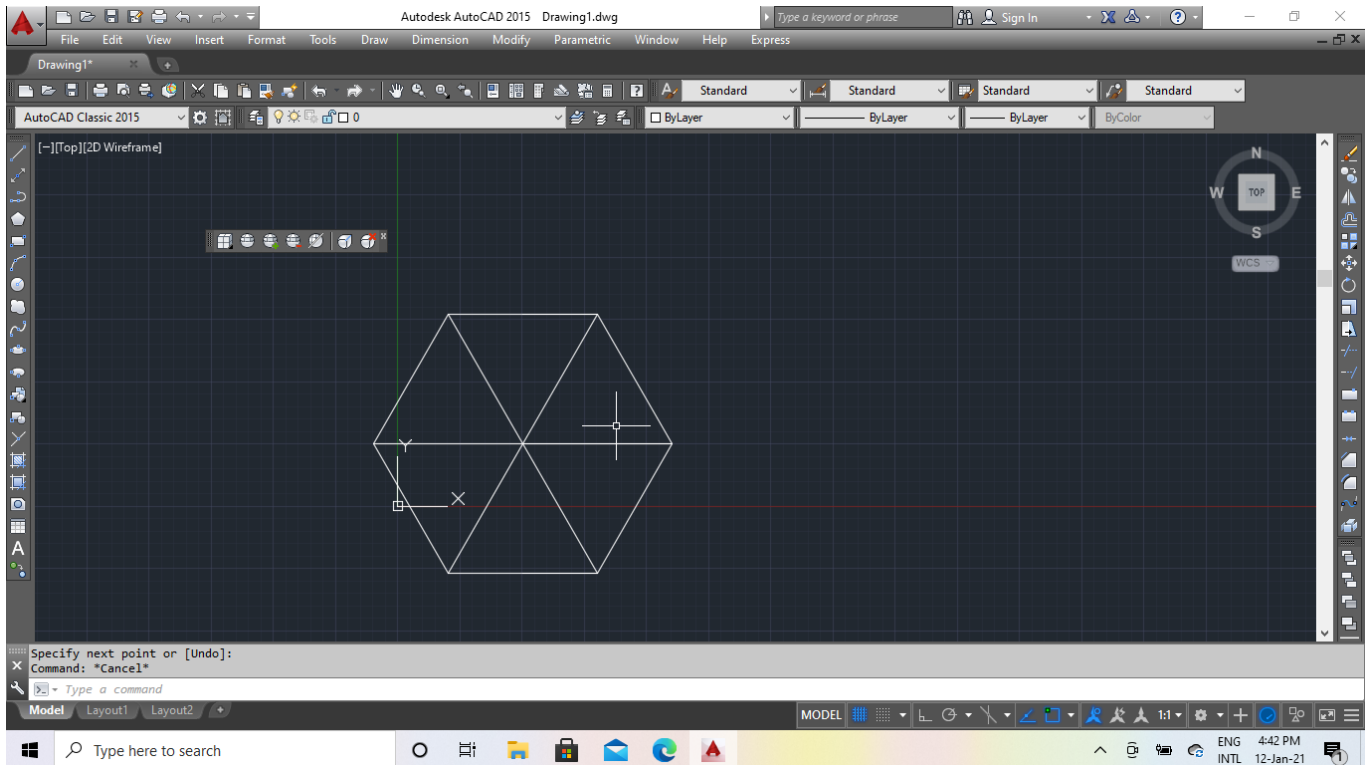
1. Select polygon in ribbon bar
or
Write pol in command window and press Enter



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

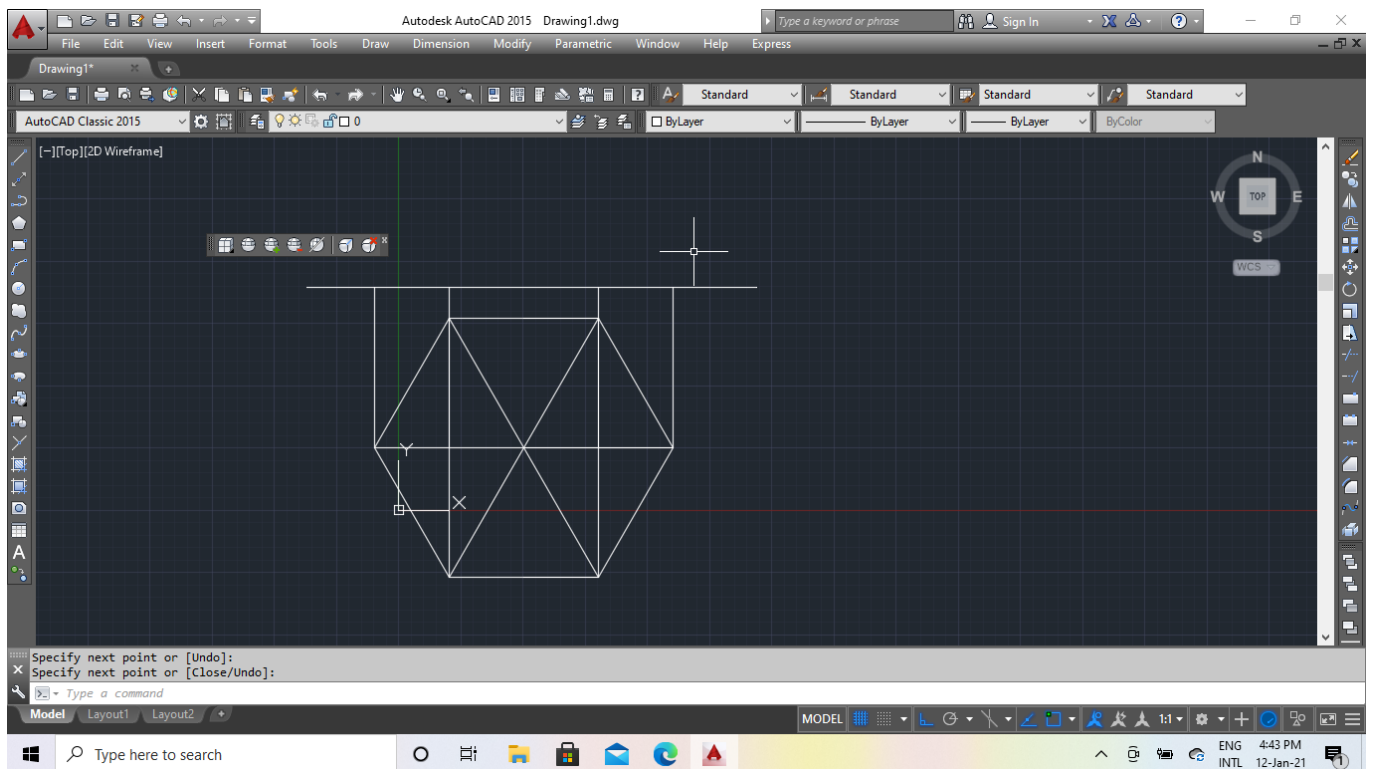
LINE Specify first point:

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: I LINE Specify first point: Specify next point or [Undo]:60

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

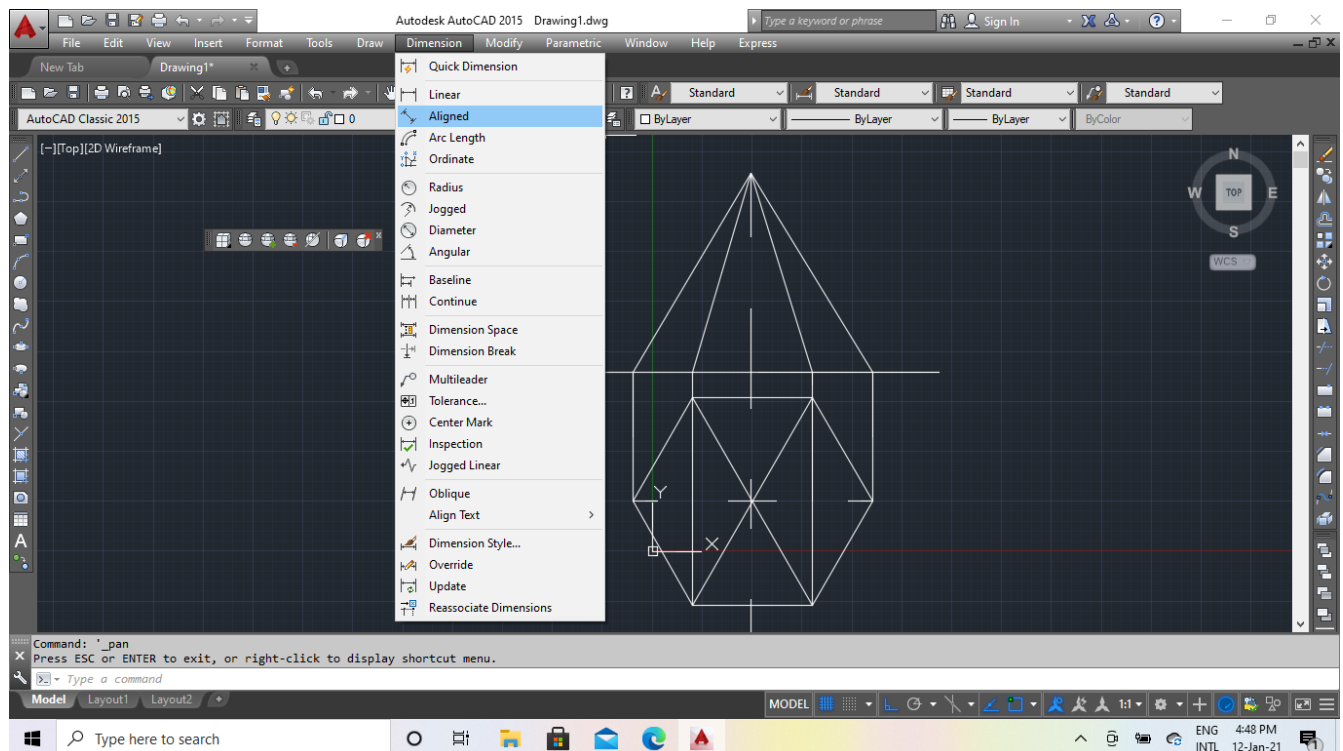


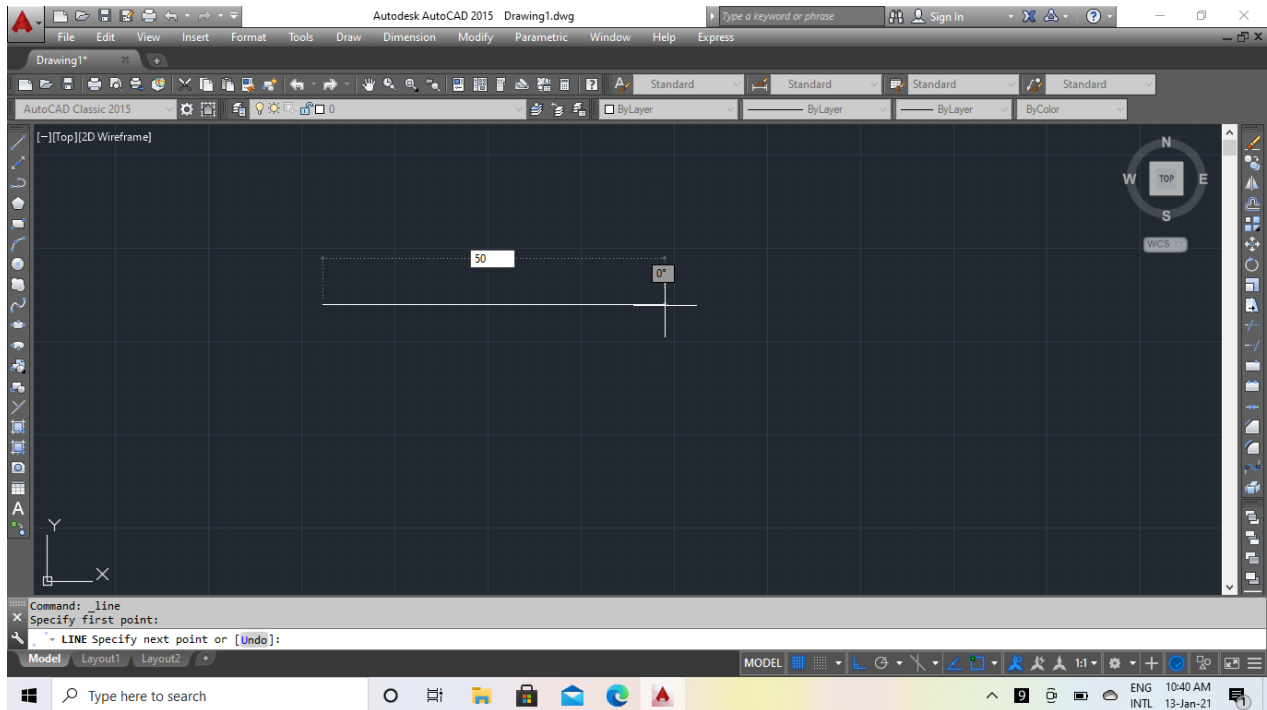
Fig 9.37

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

Q.No. 4. Draw the isometric view of a hexagonal prism side of base 20mm and height 40mm resting on the ground in vertical position and one of the side of the hexagon is parallel to V.P.

1. Command: I LINE

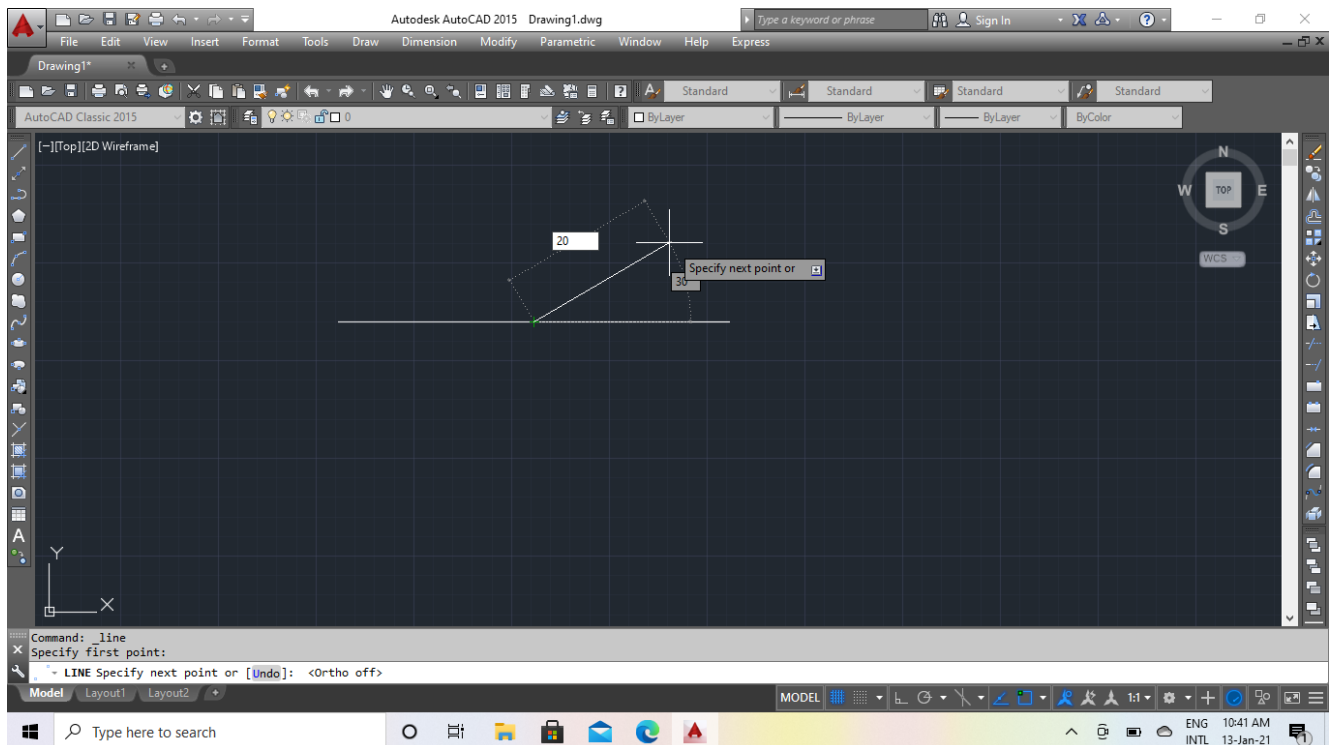
Specify first point:



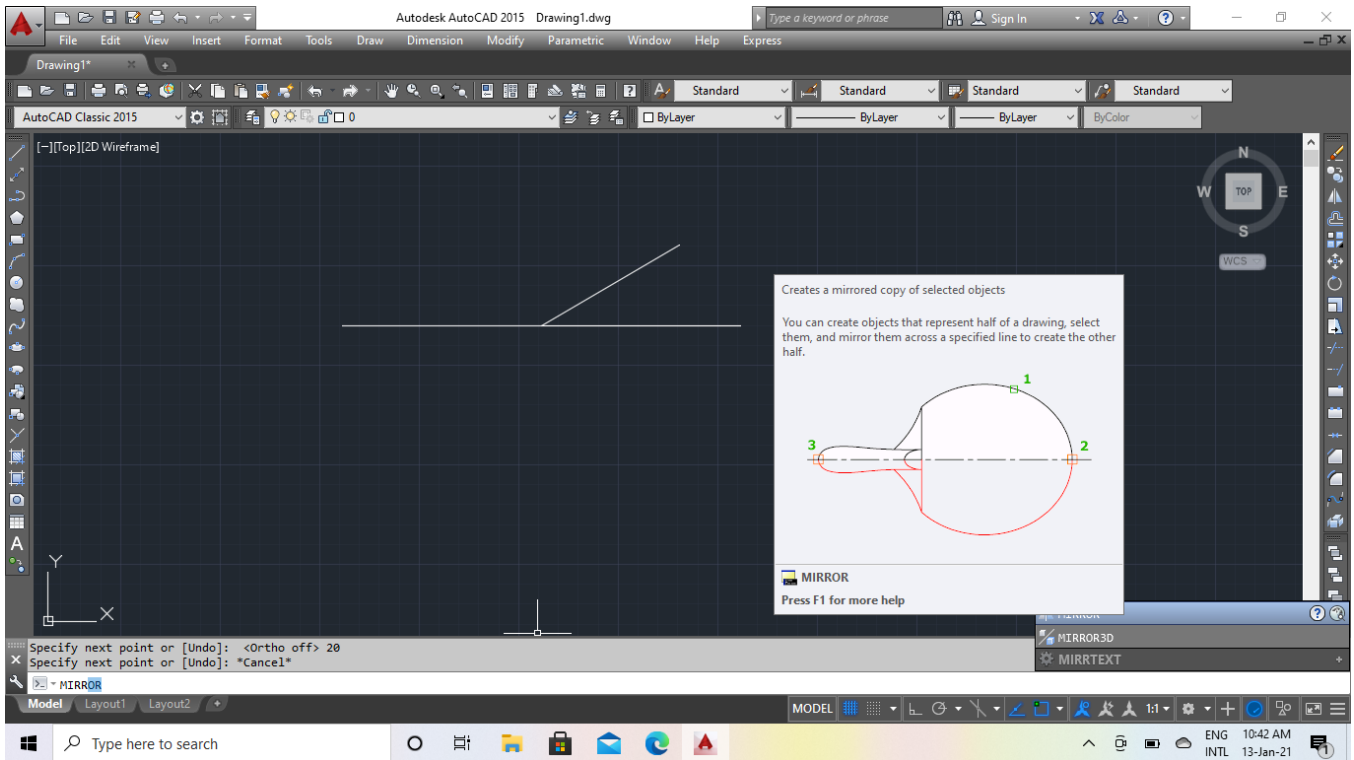
2. Command: I

LINE Specify first point:

Specify next point or [Undo]: @20<30



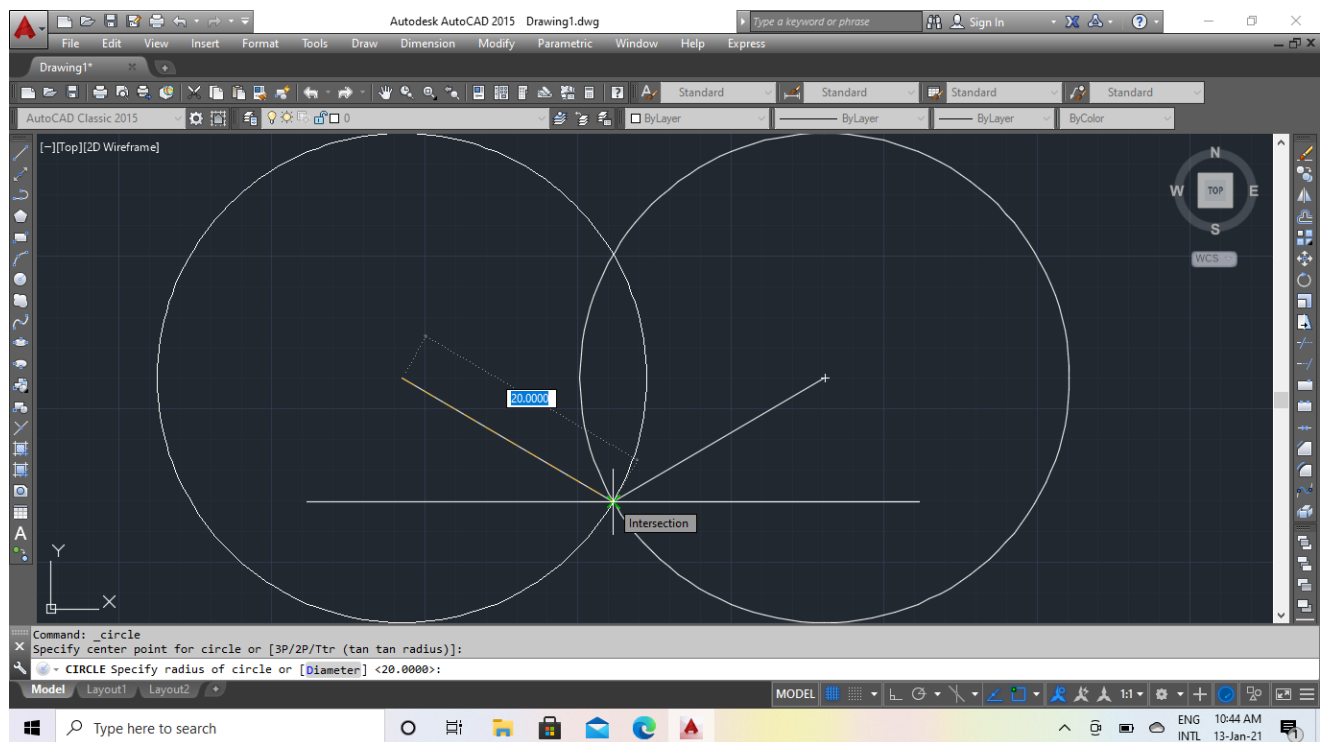
3. Mirror to opposite side.



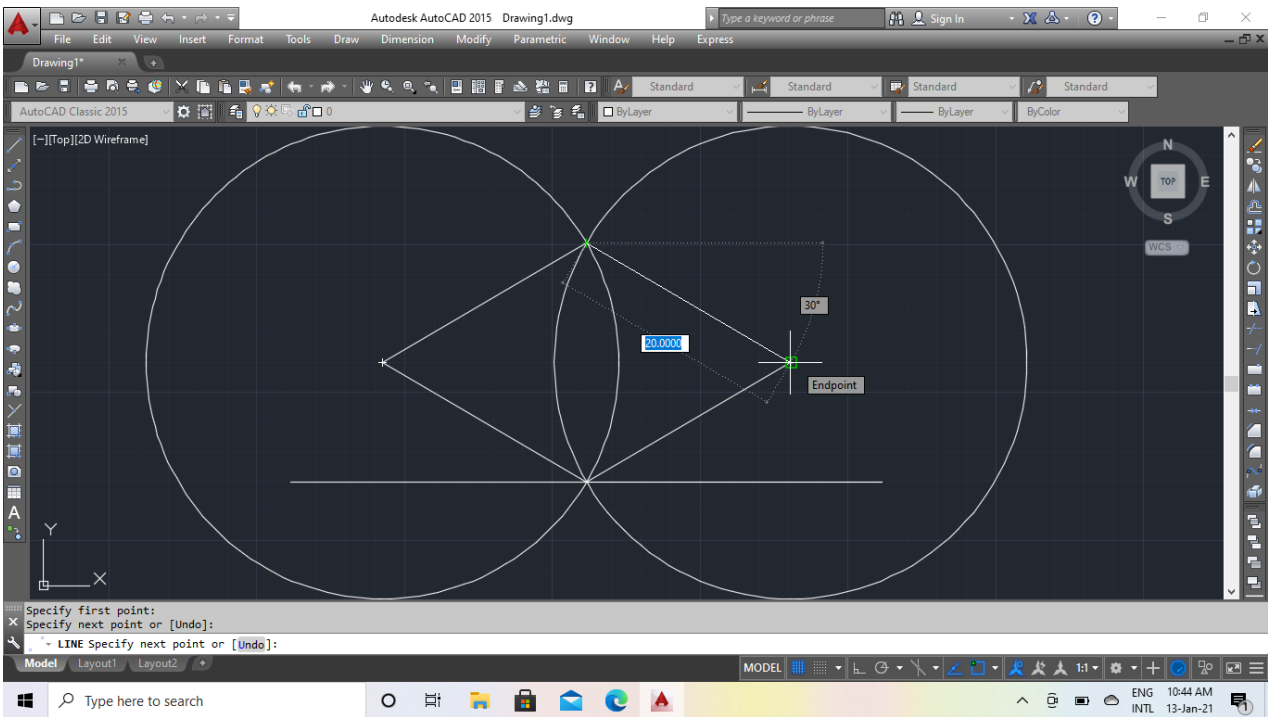
4. Command: c CIRCLE

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

Specify radius of circle or [Diameter] <20>: 40



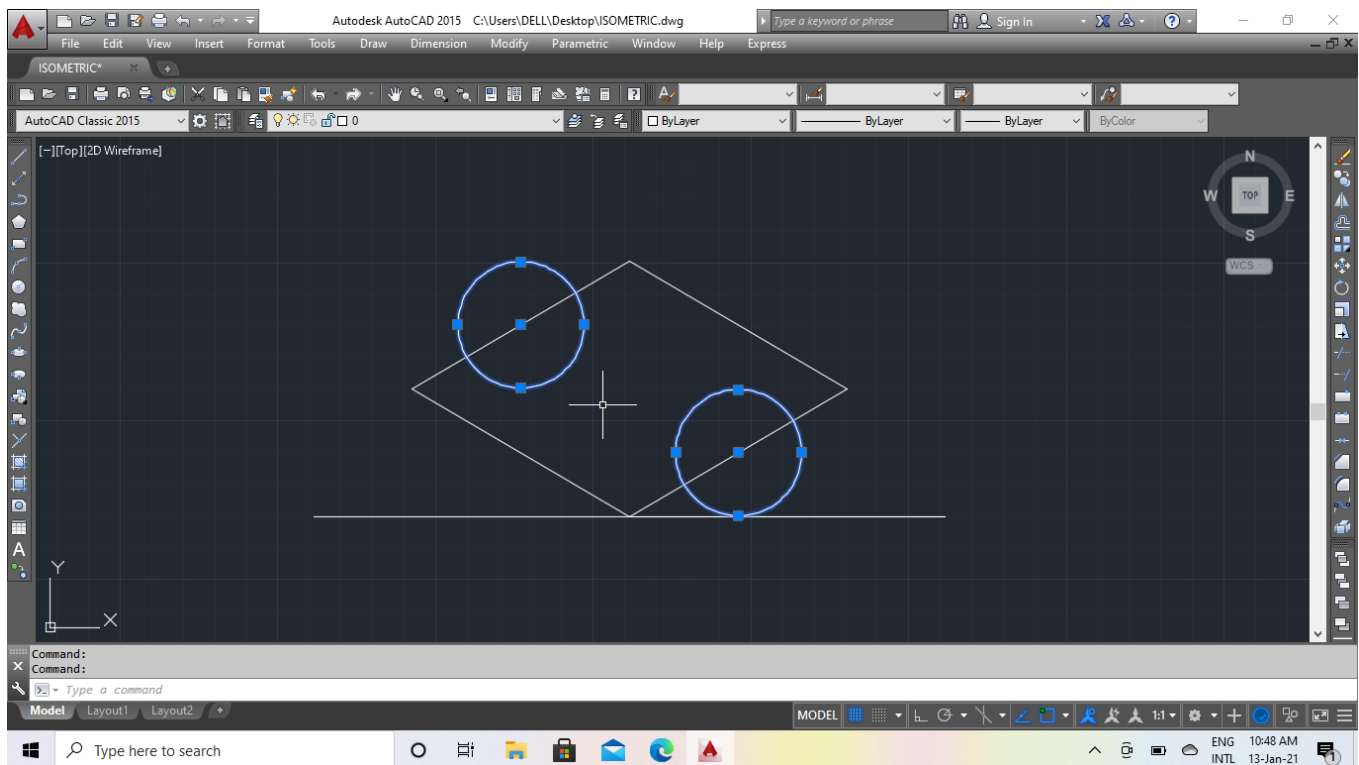
5. Then join the lines circles intersection point & delete the circle.



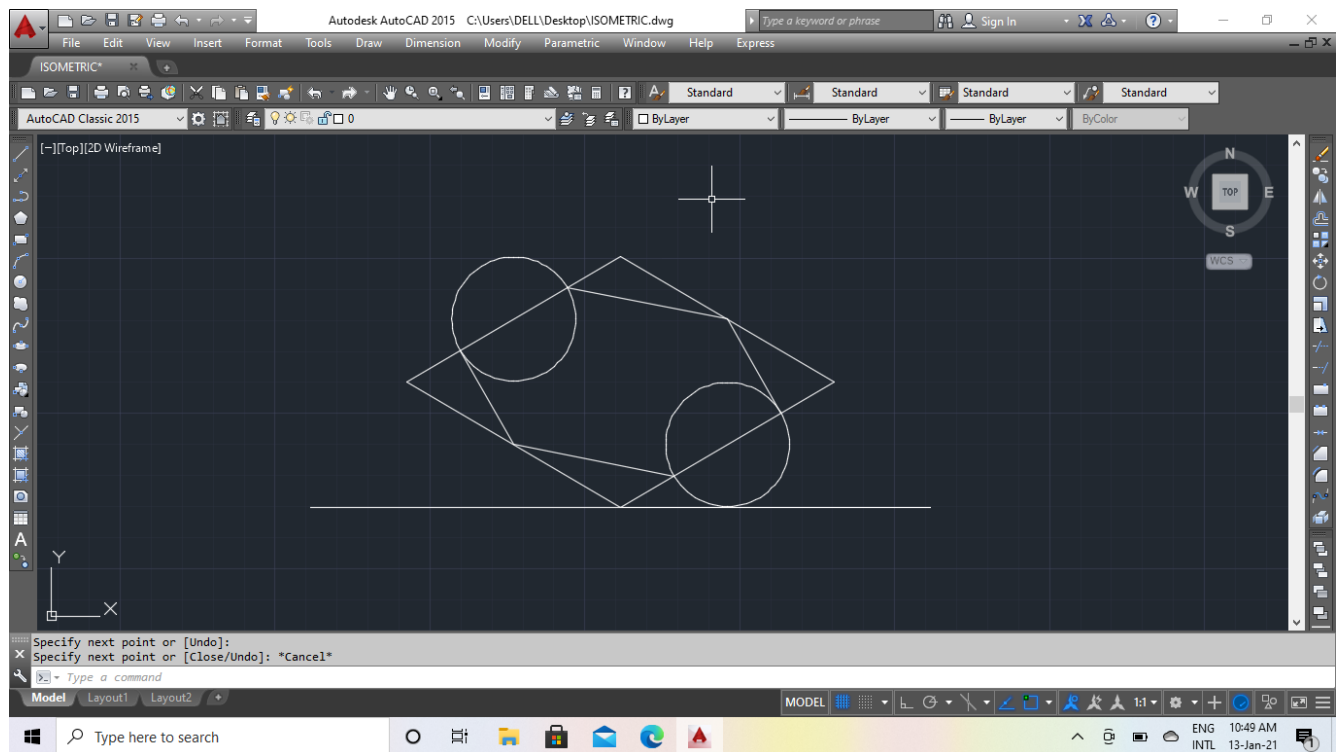
6. Draw a circle in the midpoint of line

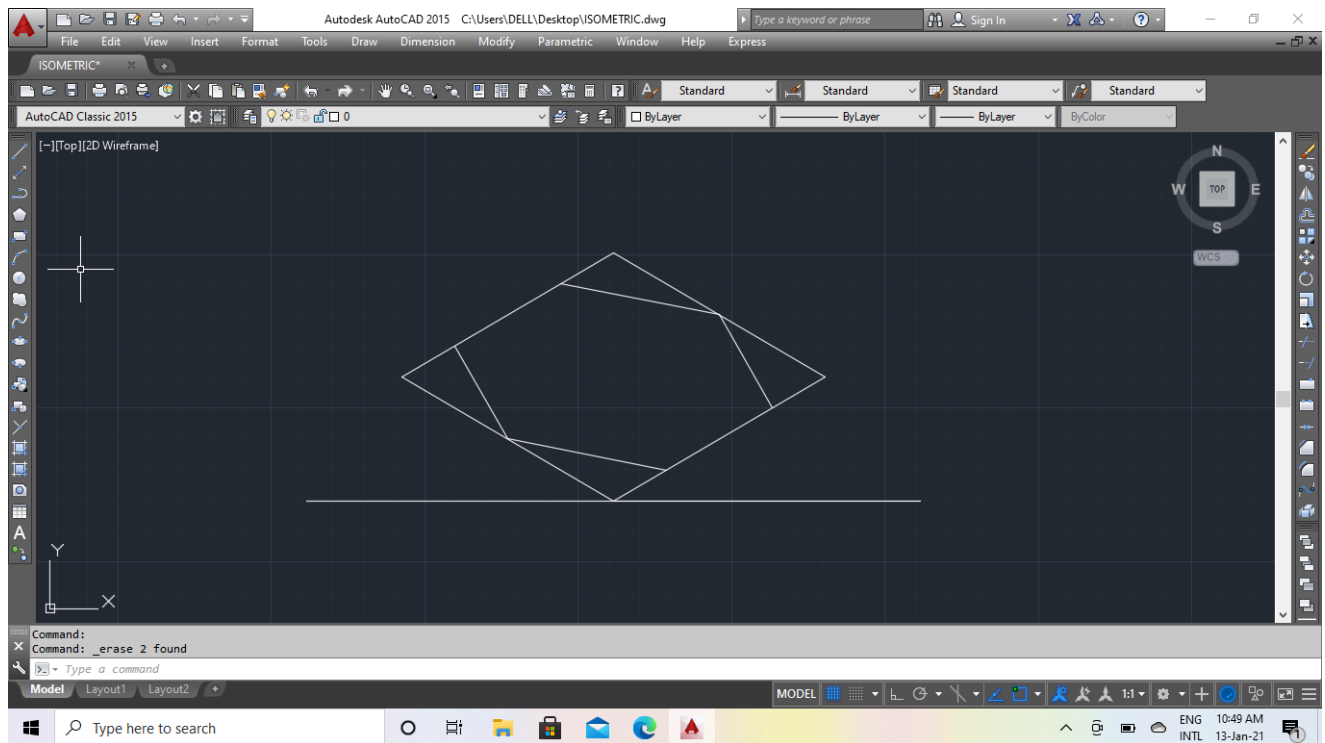
Command: CIRCLE Specify center point for circle or [3P/2P/Ttr (tan tan radius)]:

Specify radius of circle or [Diameter] <20>: d Specify diameter of circle <40>: 20

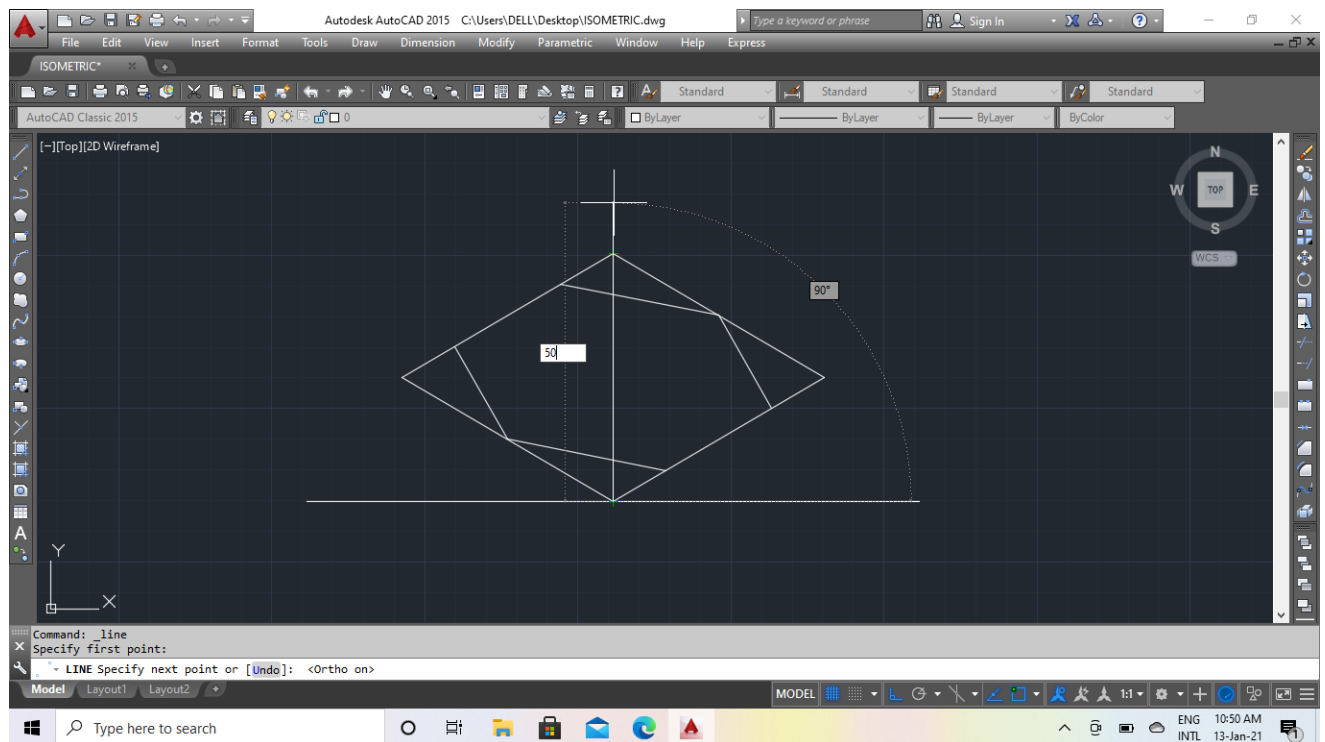


7. Join the line & delete the circle.

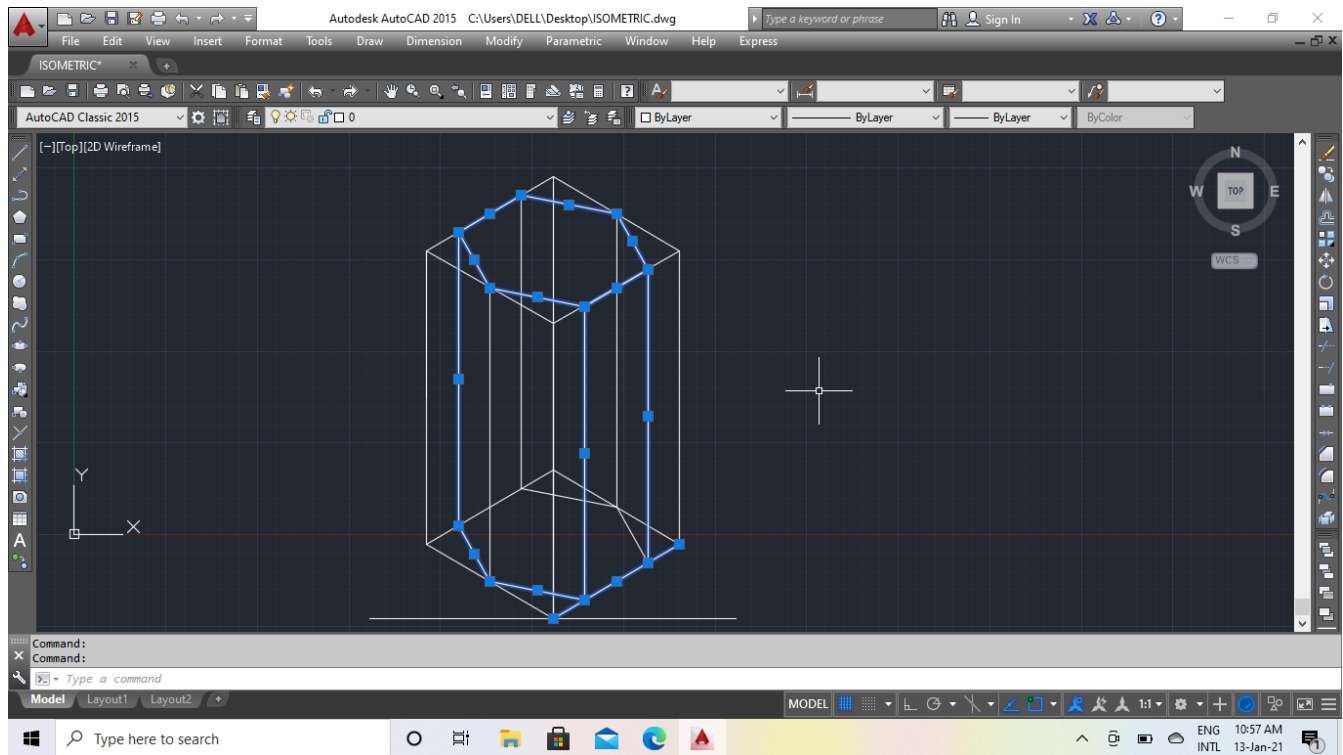




8. Then copy the object from perpendicular distance 40.



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.

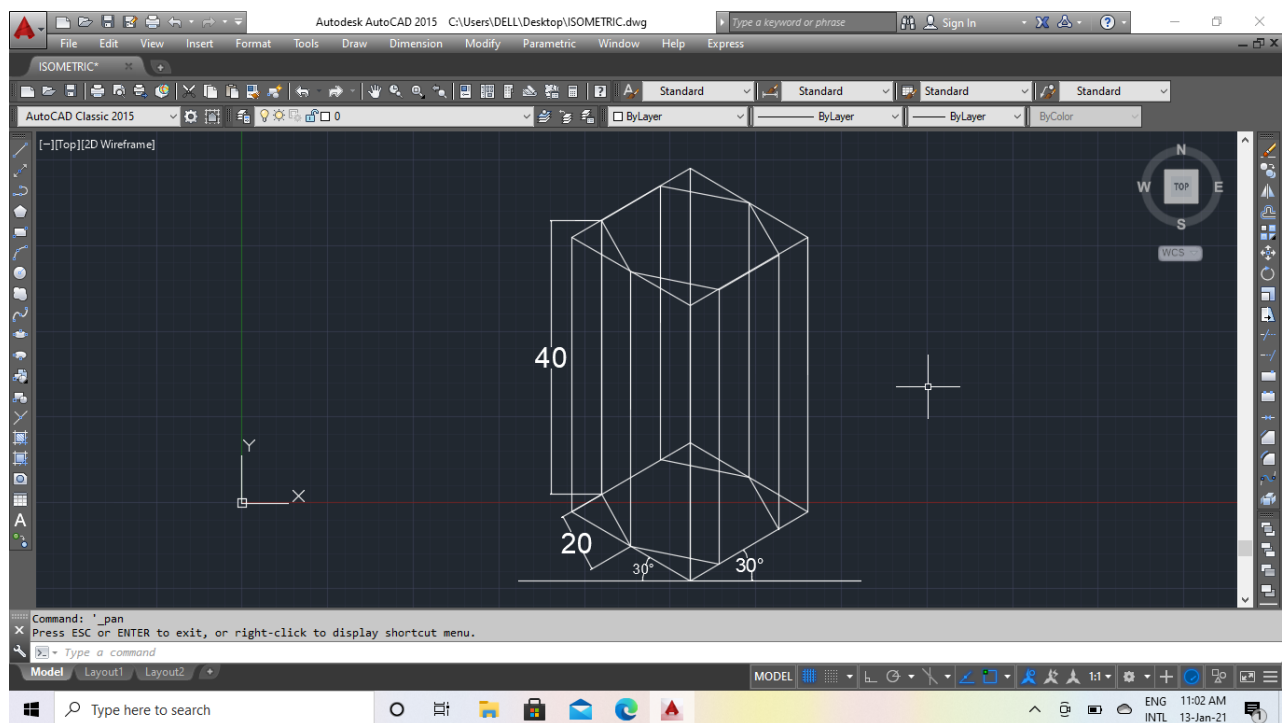
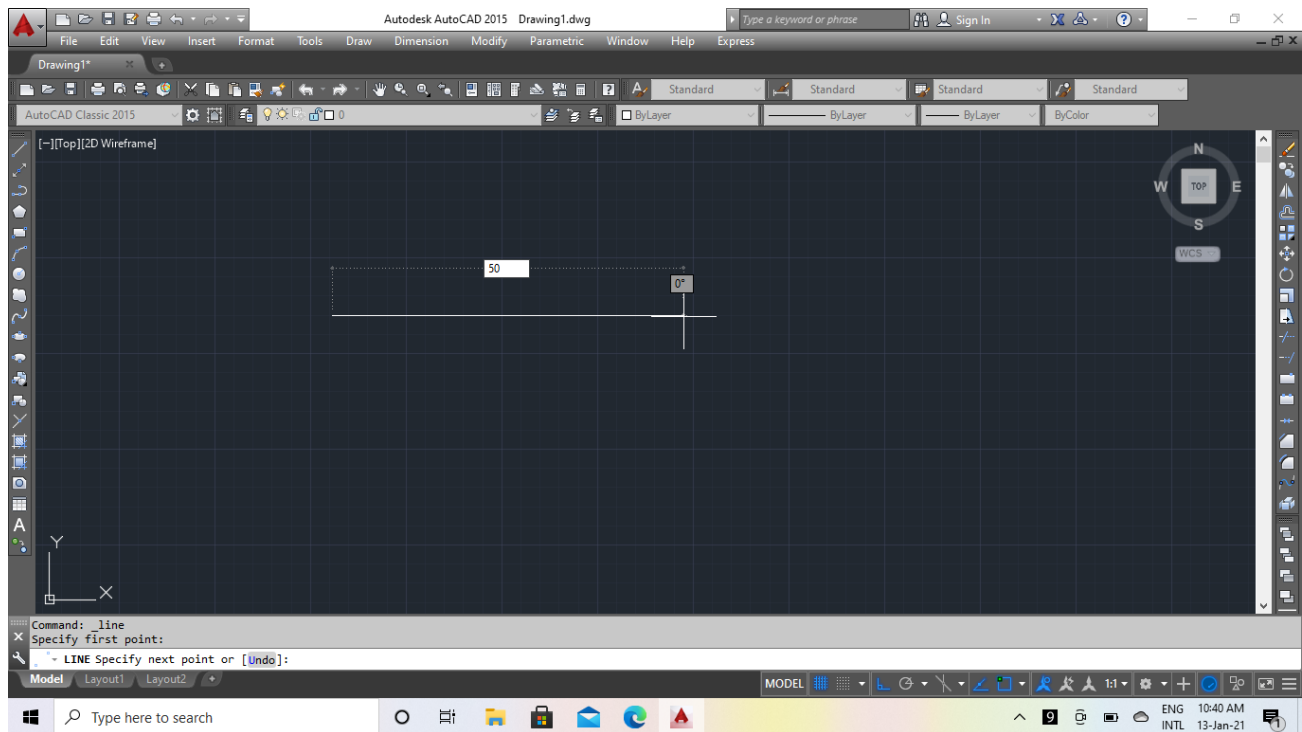


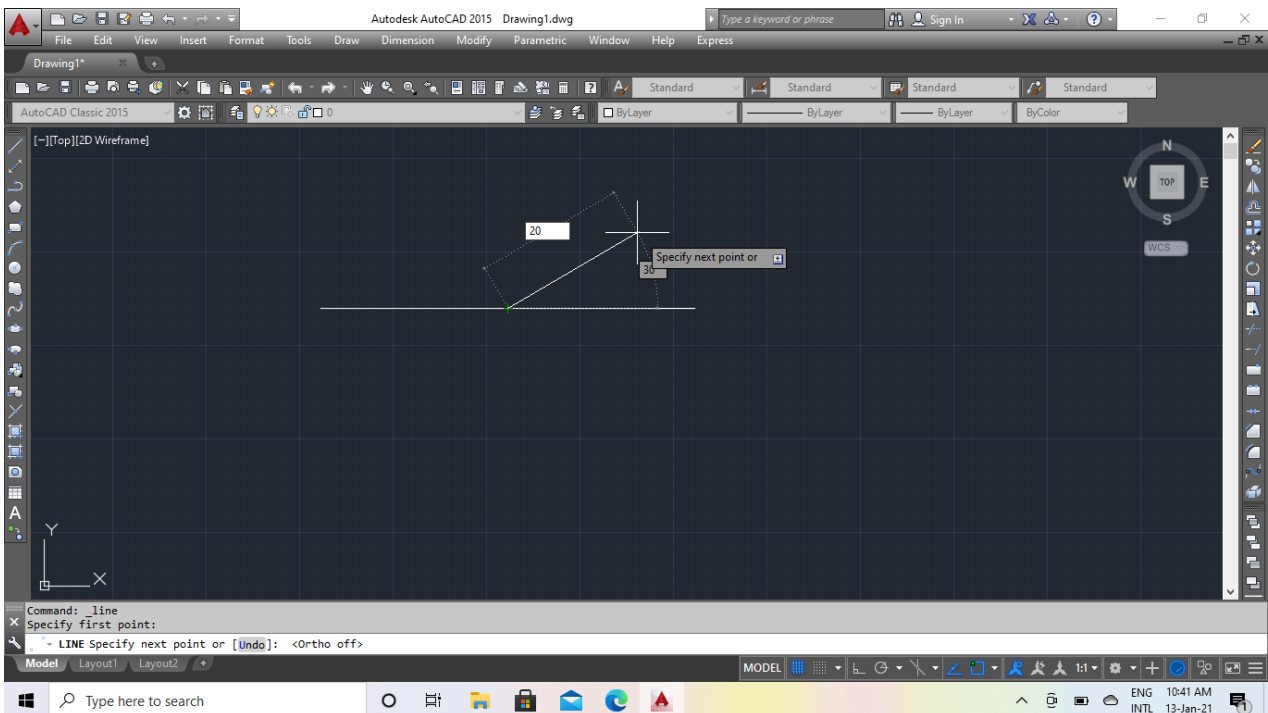
Fig 9.38

Q. No. 5. Draw the isometric view of a hexagonal pyramid of side 40mm and height 65mm, when it is resting on H. P. such that an edge of base is parallel to V.P

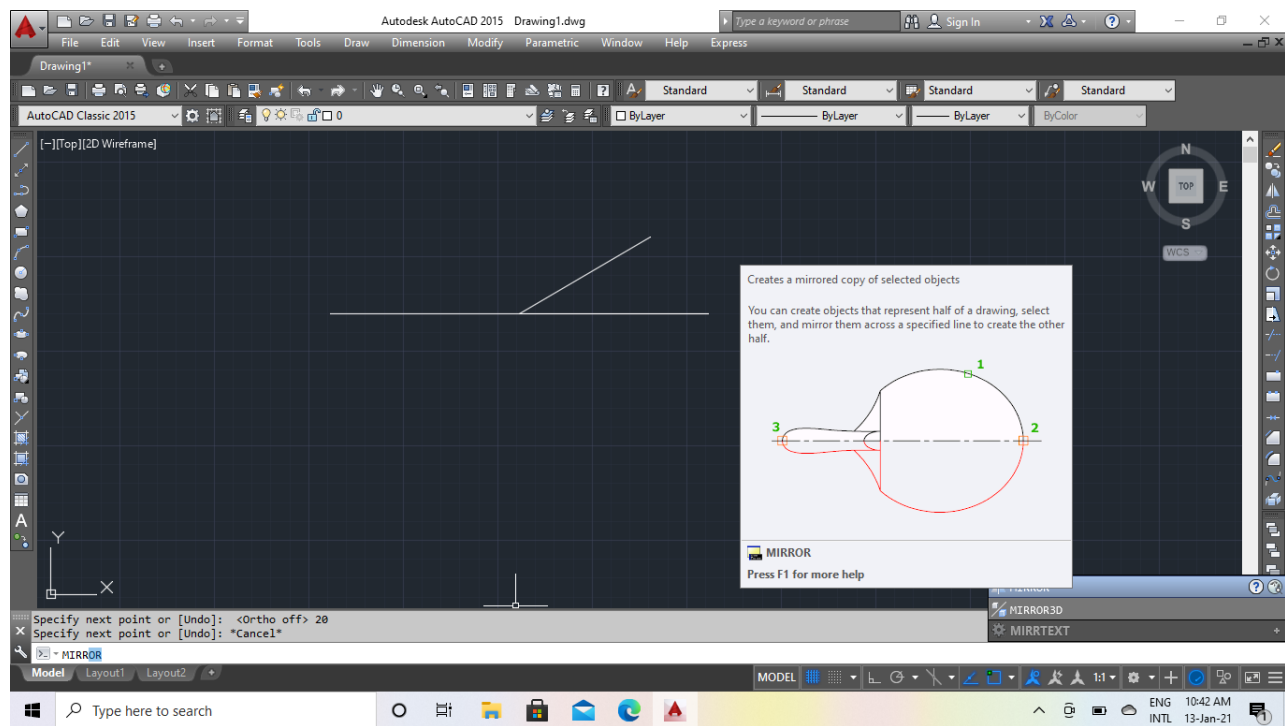
1. Command: I LINE Specify first point:



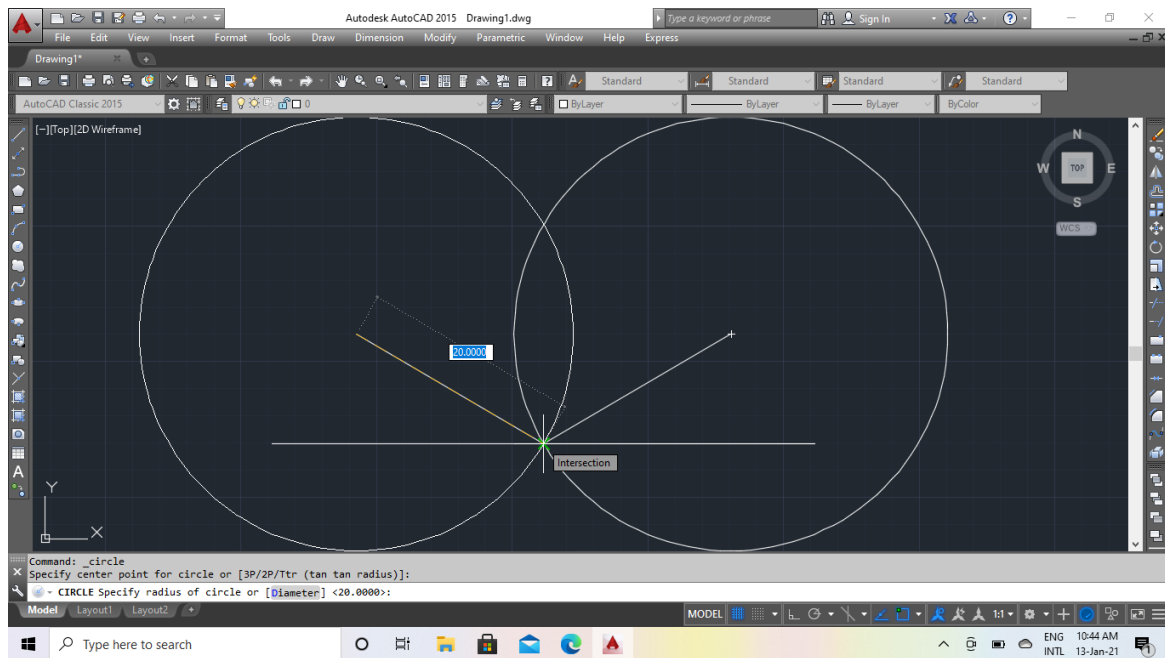
2. Command: I LINE Specify first point: Specify next point or [Undo]:@80<40



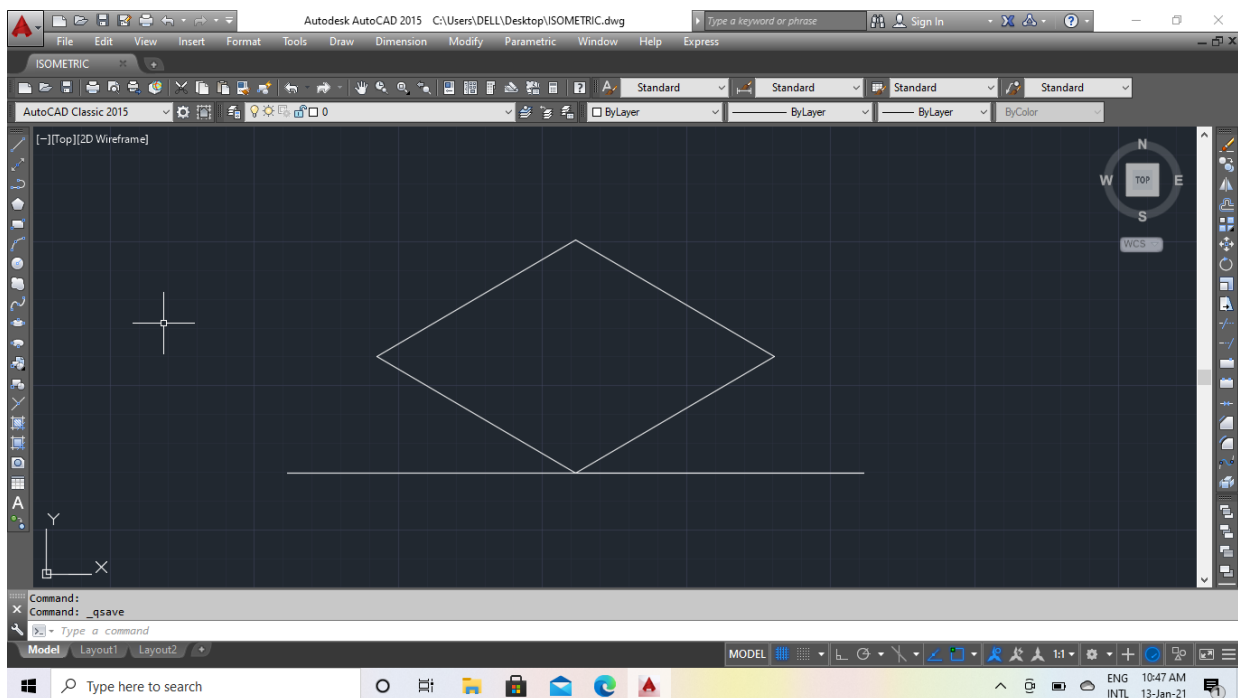
3. Mirror to opposite side.



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

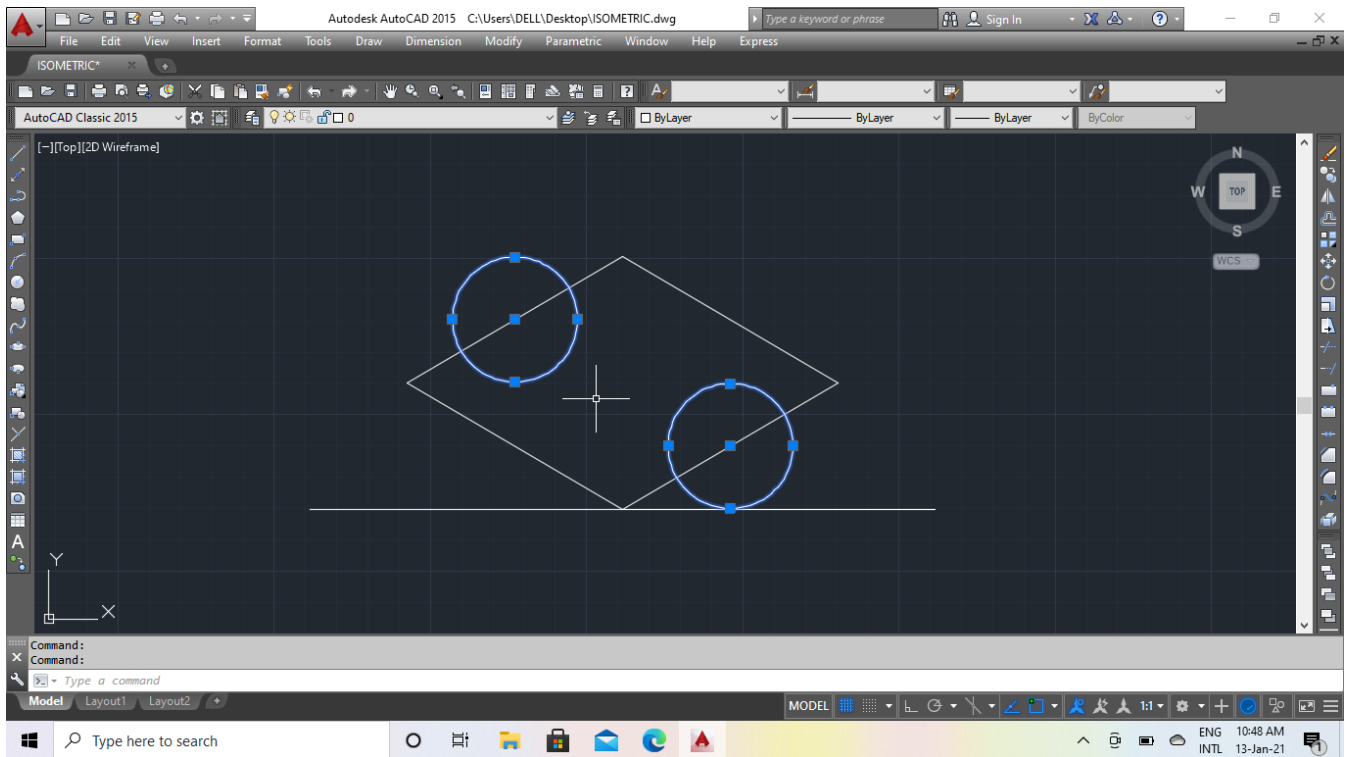


5. Then join the lines circles intersection point & delete the circle

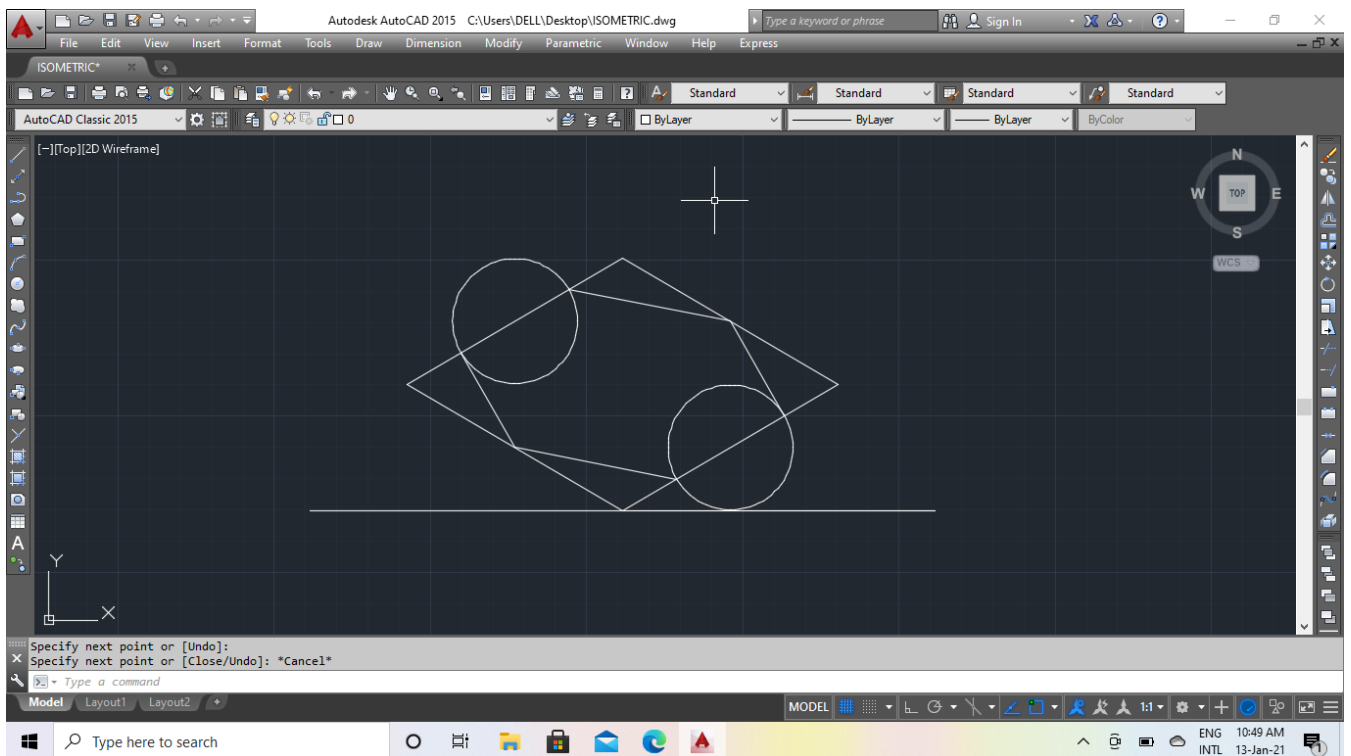


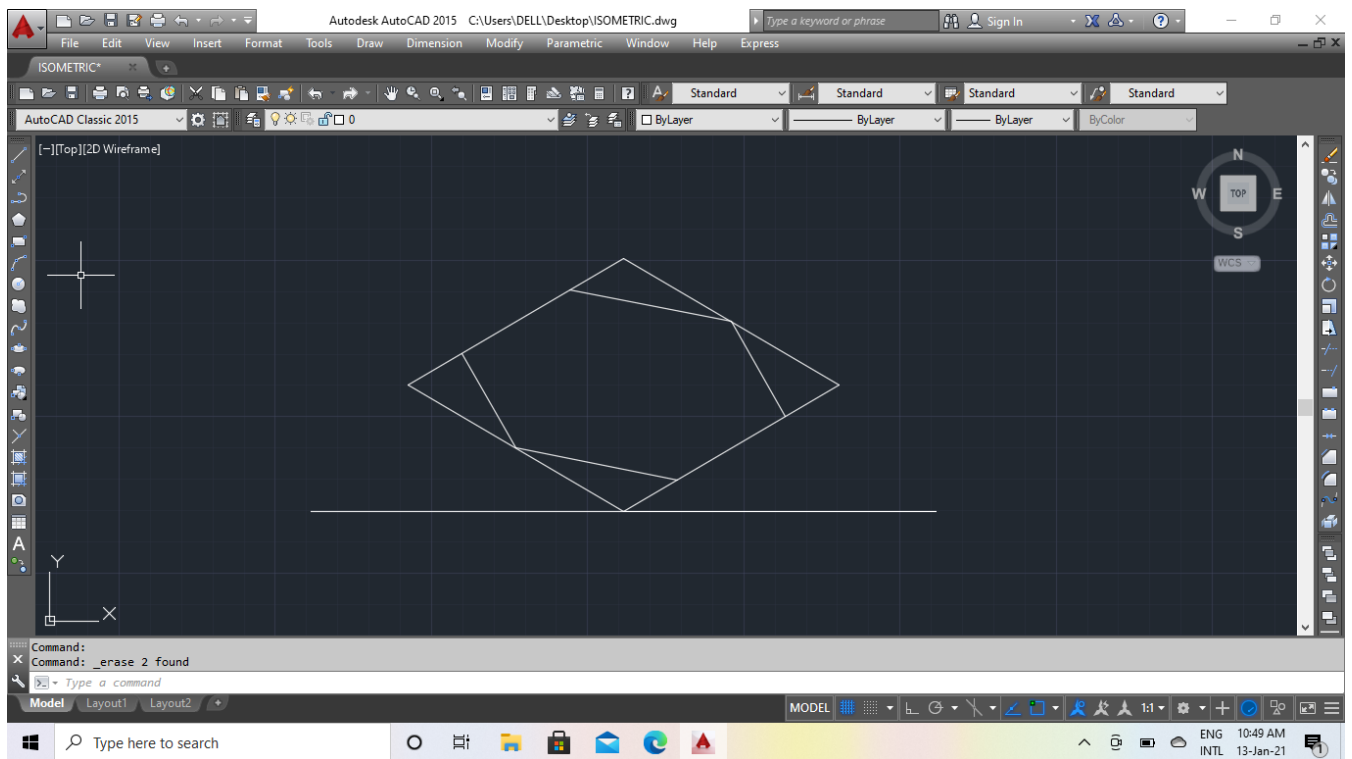
6. Draw a circle in the midpoint of line.

Command: CIRCLE Specify center point for circle or [3P/2P/Ttr (tan tan radius)]:
Specify radius of circle or [Diameter] <20>: d Specify diameter of circle <40>: 20

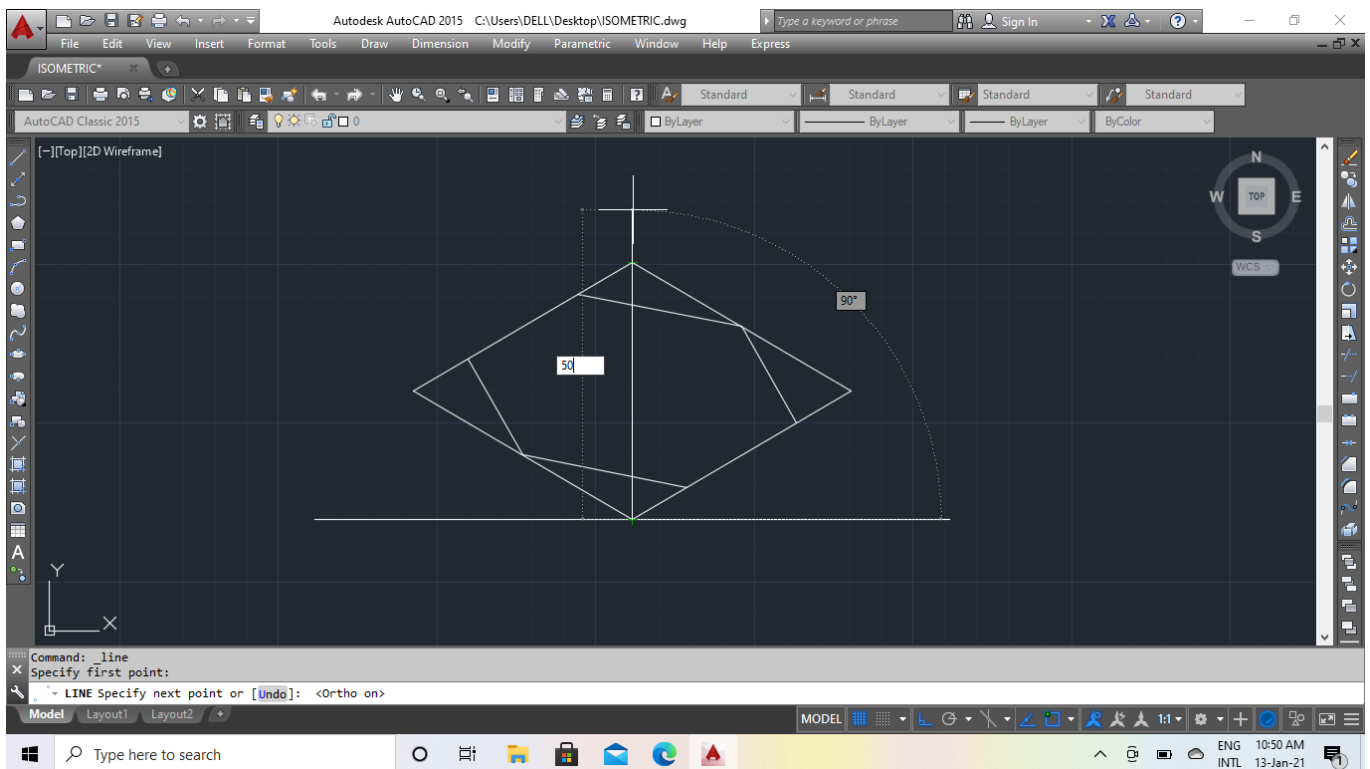


7. Join the line & delete the circle.

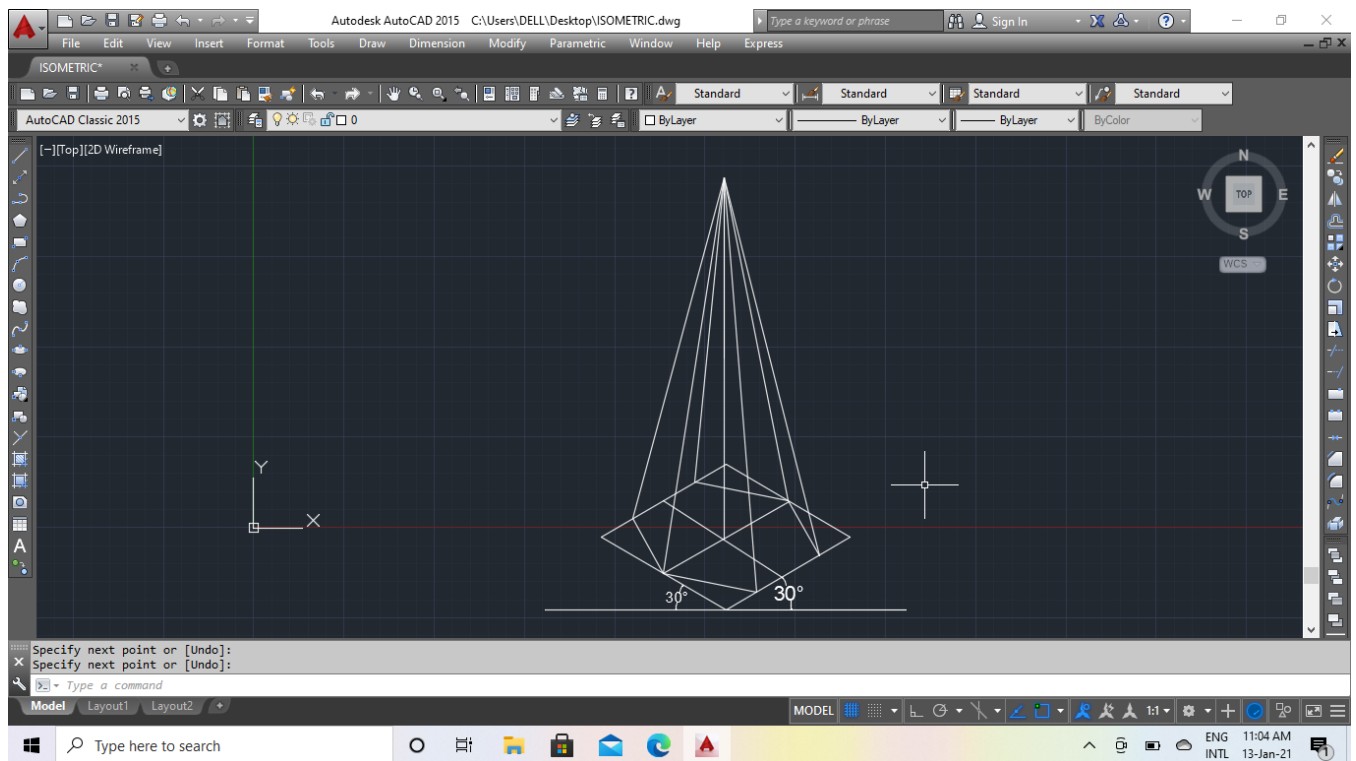




8. Line enter centre point distance 65.



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.

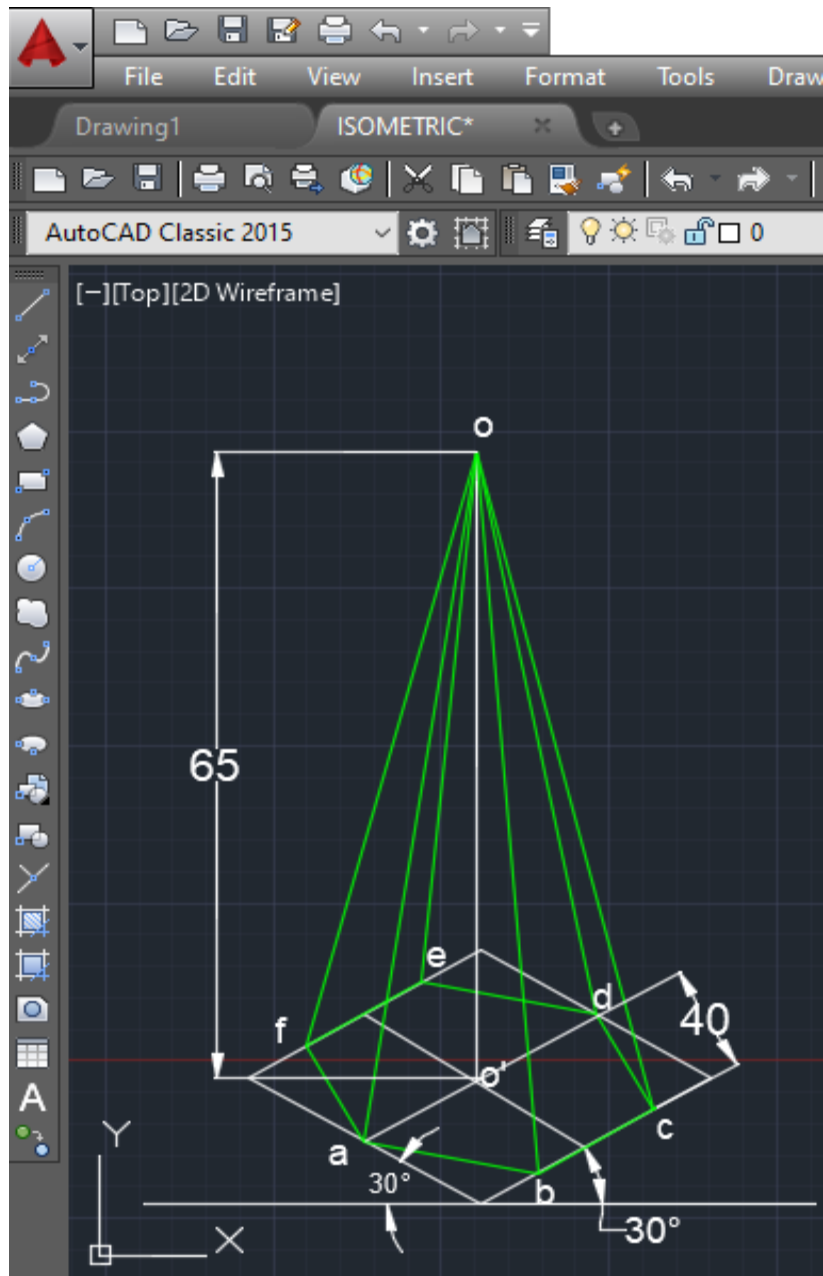


Fig 9.39

EXERCISES (TO BE PRACTICED USING AUTO CAD)

1. A line CD 60mm long is inclined at an angle of 35° to V.P. and 45° to H.P. The point C is 30mm in front V.P. and 20mm above of V.P. Draw the projection of the straight line CD.
2. Draw the projection of a circle of 10cm diameter having its plane vertical and inclined at 45° to V.P. Its centre is 5cm above the H.P. and 4cm in front of the V.P.
3. Draw the projection of a pentagonal pyramid base 55mm edge and axis 80mm 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 35mm and axis 65mm long resting with its base on H.P. such that one of its rectangular faces is parallel to and 20mm in front of V.P.
5. Draw the isometric view of a hexagonal 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.
6. Draw the isometric projection of a regular pentagonal prism side of base 35mm and axis 55mm long resting with its base on V.P. such that one of its rectangular faces is perpendicular to H.P.

REFERENCES:

1. A Text Book of Engineering Drawing By N.D. Bhatt
2. Text Book of Engineering Drawing By Er. S.K Samal
3. A Introduction to Auto CAD By George Omura, Willey India Publishers
4. Text Book of Engineering Drawing By K Venkata Reddy
5. A Text Book of Engineering Drawing By Dr. R.K Dhawan
6. A Text Book of Engineering Graphics & Auto CAD By K. Venugopal.