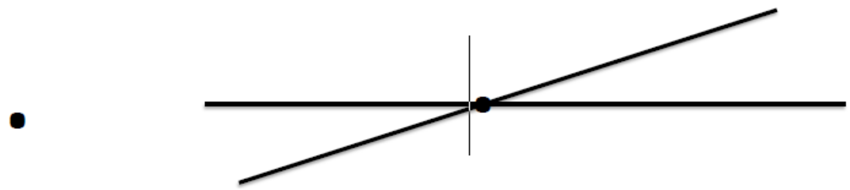
## GEOMETRICAL CONSTRUCTIONS

Engineering drawing consists of a number of geometrical constructions. A few methods are illustrated here without mathematical proofs.

### Points

1.A point represents a location in space or on a drawing, and has no width, height and depth.
2.A point is represented by the intersection of two lines.



### Lines

1.Astraightlineistheshortestdistancebetweentwopointsandiscommonlyreferredas“Line”.
2.It as length and no width.

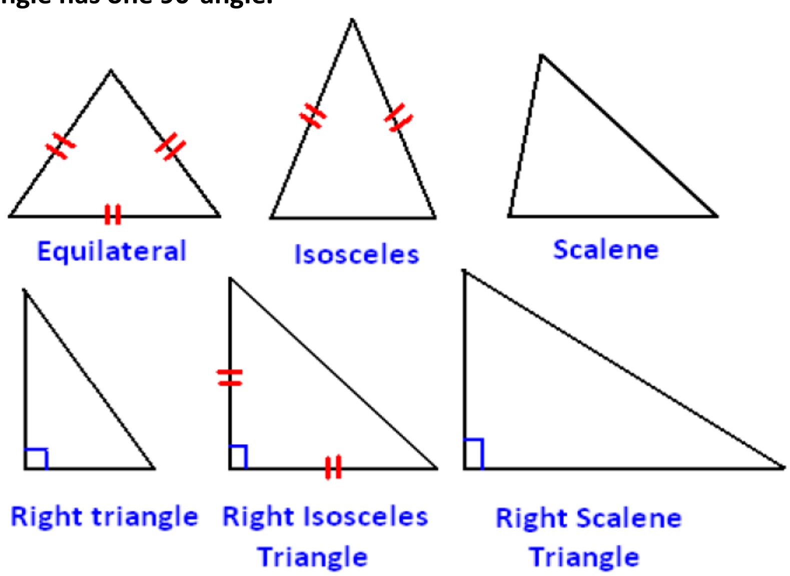
### Angles

**1.An Angle is formed between two intersecting lines.**

**2.A common symbol for angle is** ∠

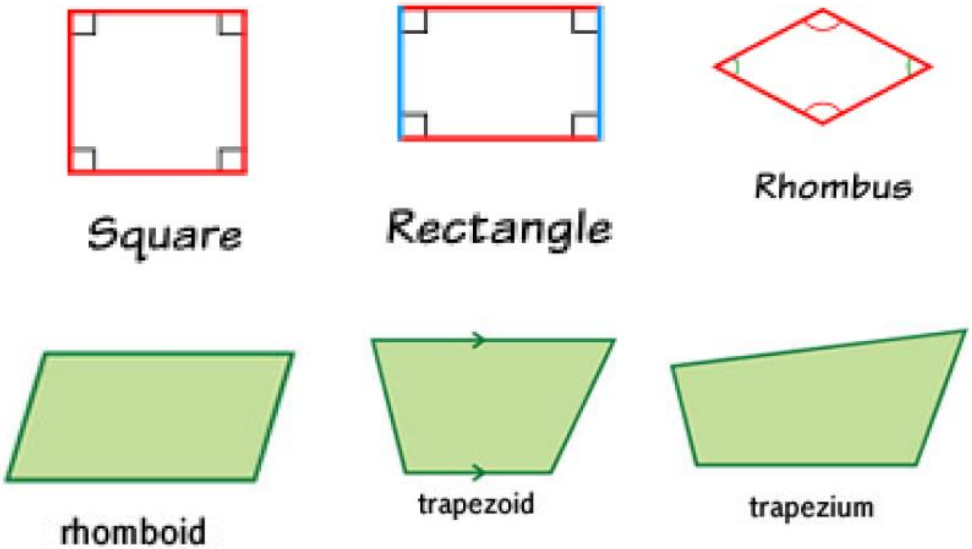
### Triangles

**1.A Triangle is a plane figure bounded by three lines, and the sum of the interior angle is always 180°.**
**2.A right angle triangle has one 90°angle.**




### Quadrilaterals

**1.A Quadrilateral is a plane figure bounded by four lines.**
**2.Inthisquadrilateralsiftheoppositesidesareparallel,thequadrilateraliscalledparallelogram.**




**Polygons**

**1.A Polygon is plane figure bounded by number of straight lines.**

**2.Ifthepolygonhasequalanglesandequalsidesandifitcanbeinscribedinorcircumscribedaroundacircle,itiscalledasRegularpolygon.**

Types of Regular polygons

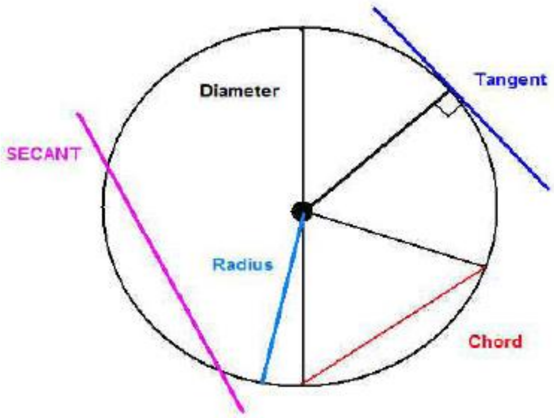
| Types | Sides | Shapes |
|---|---|---|
| Triangle | 3 | |
| Square | 4 | |
| Pentagon | 5 | |
| Hexagon | 6 | |
| Heptagon | 7 | |
| Octagon | 8 | |
| Nonagon | 9 | |
| Decagon | 10 | |
| Hendecagon | 11 | |
| Dodecagon | 12 | |

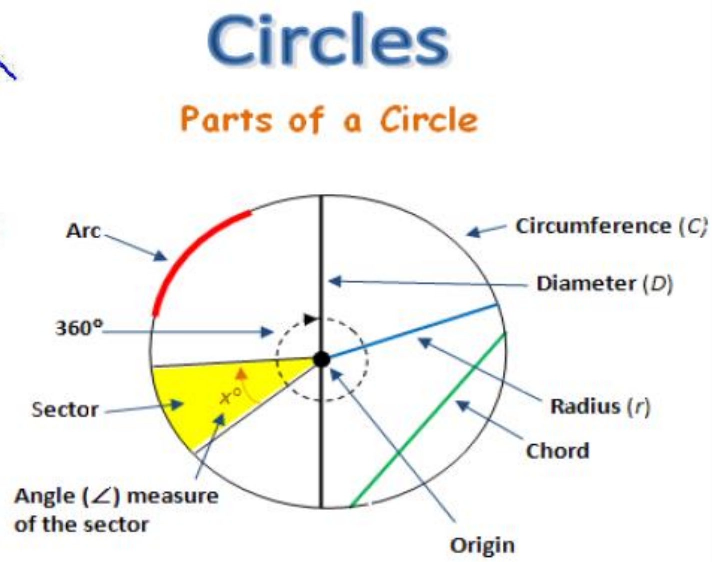
**Circles and Arcs**

**1.ACircleisaclosedcurveandallpointsofwhichareatthesamedistancefromapointcalledthecenter.**

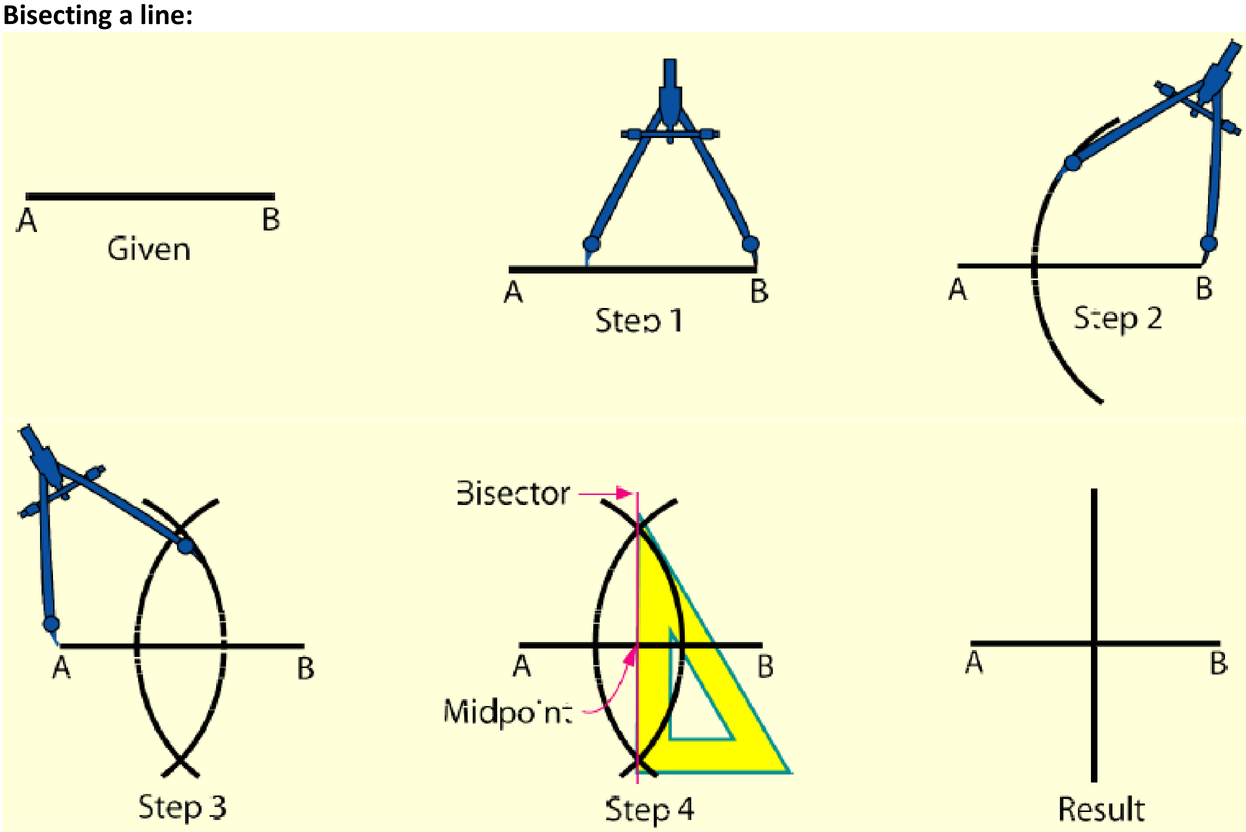
**2.Circumferencereferstothedistancearoundthecircle.**

**3.Ifnumberofcirclesofcircleshaveasamecenter,theyarecalledasConcentriccircles.**

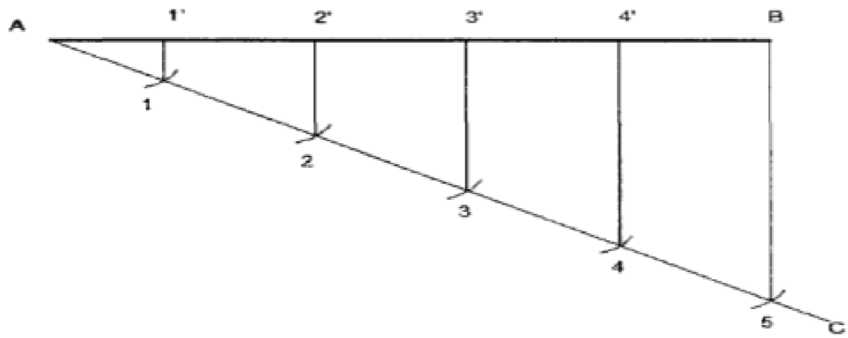



**Bisecting a line:**



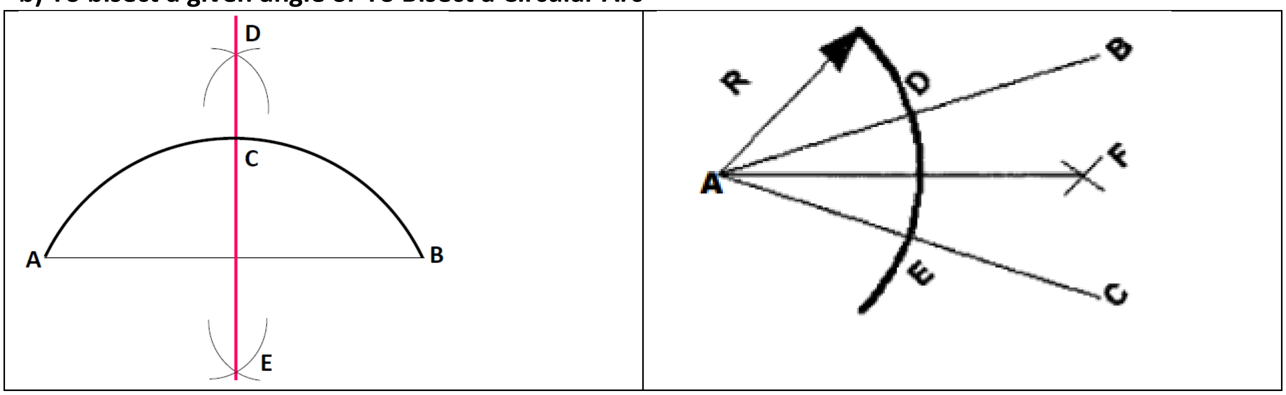

**1. a) To divide a straight line into a given number of equal parts say 5.**




Construction:

1. Draw AC at any angle $\theta$ to AB
2. Construct the required number of equal parts of convenient length on AC like 1,2,3,4 and 5.
3. Join the last point 5 to B
4. Through 4, 3, 2, 1 draw lines parallel to 5B to intersect AB at 4',3',2' and 1'.

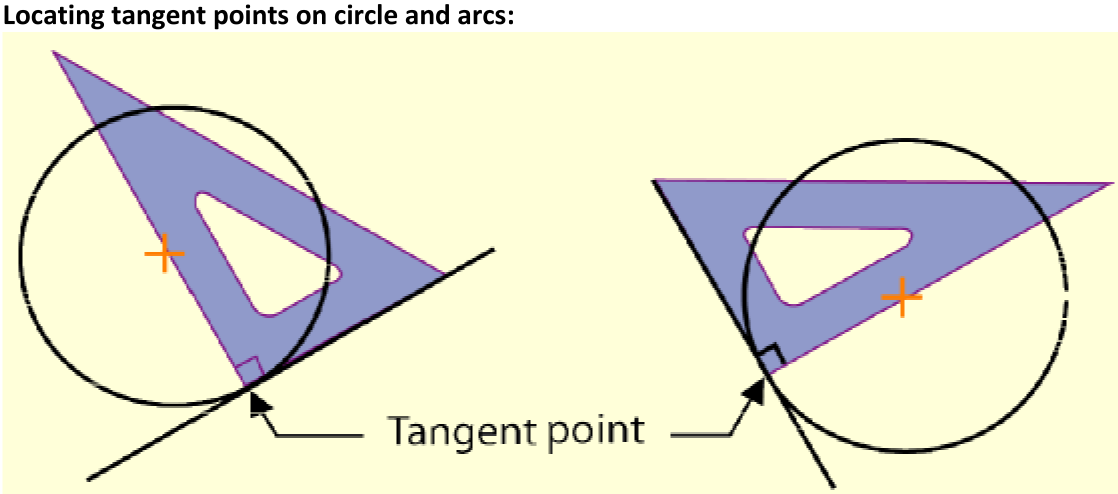
**b) To bisect a given angle or To Bisect a Circular Arc**



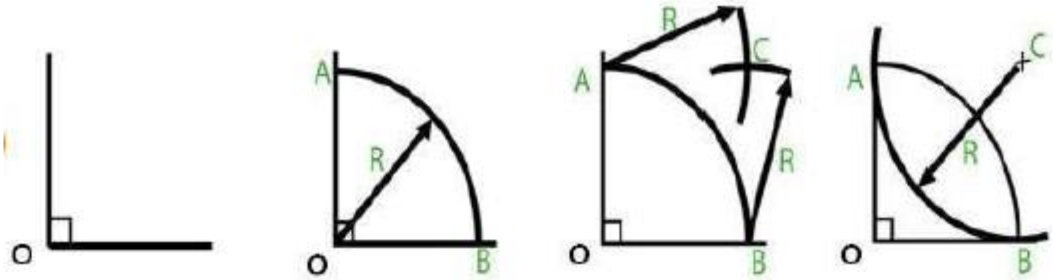

**Construction:**

1. Draw a line AB and AC making the given angle.
2. With centre A and any convenient radius R draw an arc intersecting the sides at D and E.
3. With centre's D and E and radius larger than half the chord length DE, draw arcs intersecting at F
4. Join AF, <BAF=<FAC.

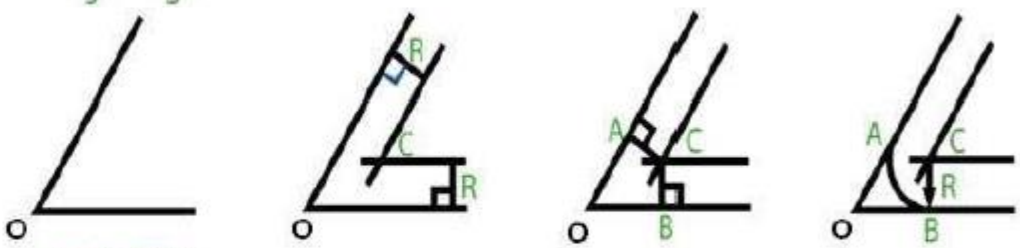
**Locating tangent points on circle and arcs:**




**Drawing an arc, tangent to two lines:**



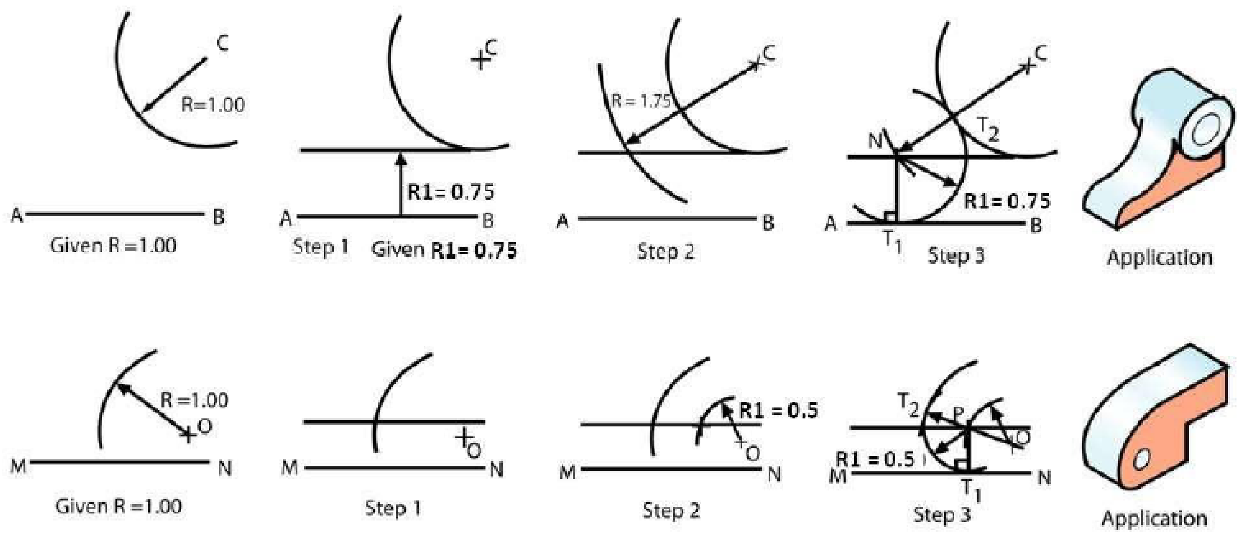

Right Angle




Acute Angle

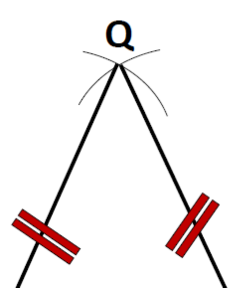
**Drawing an arc, tangent to a line and an arc:**

**(a) that do not intersect** **(b) that intersect**




**To Construct an Isosceles Triangle**

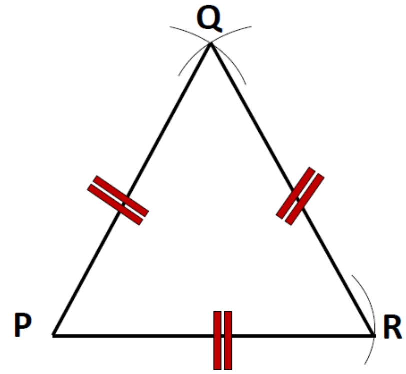
1. Mark a point P that will become one vertex of the triangle.
2. Mark a point R on arc. PR will be the base of the triangle.
3. Draw the base PR of the triangle.
4.With Points P and R as centres and radius R, equal to the length of the sides, draw intersecting arcs to locate the vertex (top point) of the triangle.



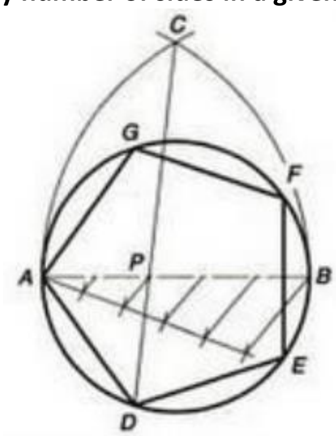
5.PQR is an isosceles triangle with the desired dimensions.

**To Construct an Equilateral Triangle**

1. Mark a point P that will become one vertex of the triangle.
2. Mark a point Q on either arc to be the next vertex.
3. Without changing the width, move to Q  and draw an arc across the other, creating R
4. Draw three lines linking P, Q and R




**2. To inscribe a regular polygon of any number of sides in a given circle.**



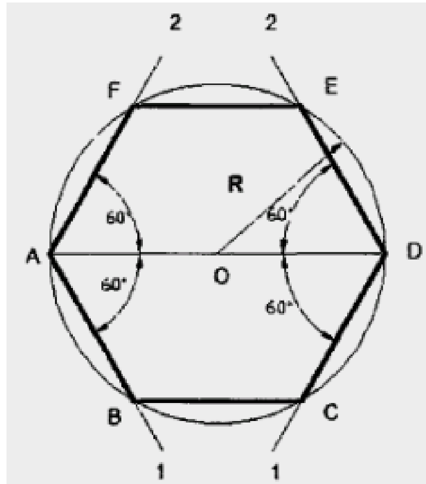

**Construction:**

1. Draw the given circle with AB as diameter.
2. Divide the diameter AB into N equal parts say 5.
3. With AB as radius and A & B as centers, draw arcs intersecting each other at C.
4. Join C-P and extend to intersect the circle at D.
5. Join A-D which is the length of the side of the required polygon.
6. Set the compass to the length AD and starting from D mark off on the circumference of the circles, obtaining the points E,F, etc. The figure obtained by joining the points A,D,E etc., is the required polygon.

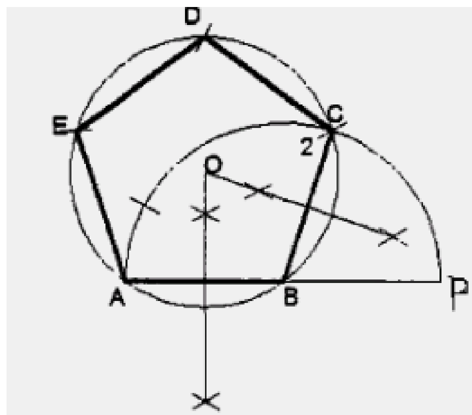
**3. To inscribe a hexagon in a given circle.**

Construction:

1. With centre O and radius R draw the given circle.
2. Draw any diameter AD to the circle.
3. Using 30° - 60° set-square and through the point A draw lines A1, A2 at an angle 60° with AD, intersecting the circle at B and F respectively.
4. Using 30°-60° set-square and through the point D draw lines Dl, D2 at an angle 60° with DA, intersecting the circle at C and E respectively.
5. By joining A,B,C,D,E,F and A,S the required hexagon is obtained.




**4. To construct a regular polygon (say a pentagon) given the length of the side.**



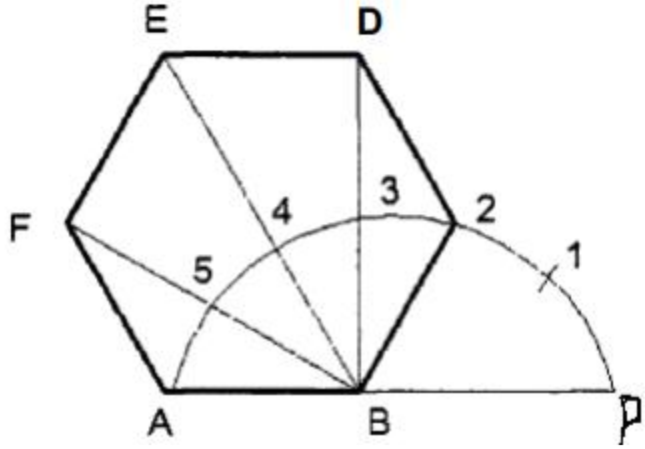

Construction:

1. Draw a line AB equal to the side and extend to P such that AB = BP.
2. Draw a semicircle on AP and divide it into 5 equal parts by trial and error.
3. Join B to second division Irrespective of the number of sides of the polygon B is always joined to the second division.
4. Draw the perpendicular bisectors of AB and B2 to intersect at O.
5. Draw a circle with O as centre and OB as radius. 6. With AB as radius intersect the circle successively at D and E. Then join CD, DE and EA.

**5. To construct a regular polygon (say a hexagon) given the side AB.**

Construction:

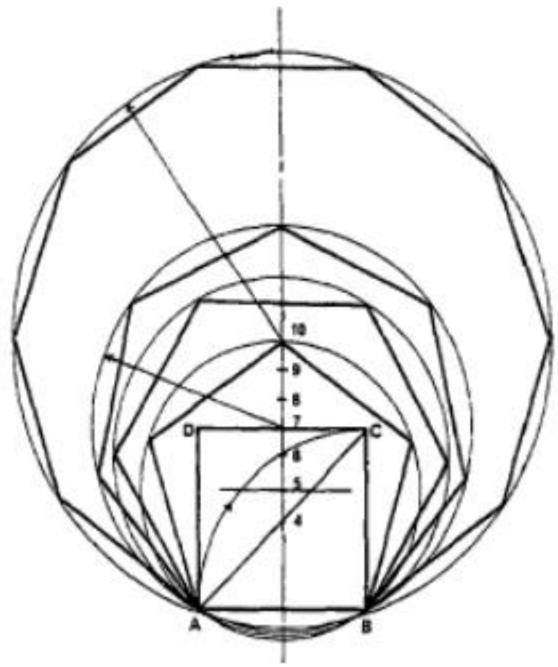
1. Draw a line AB equal to the side and extend to P such that AB = BP
2. Draw a semicircle on AP and divide it into 6 equal parts by trial and error.
3. Join B to second division.
4. Join B- 3, B-4, B-5 and produce them.
5. With 2 as centre and radius AB intersect the line B, 3 produced at D. Similarly get the point E and F.
6. Join 2- D, D-E, E-F and F-A to get the required hexagon.




**6) To construct a regular figure of given side length and of N sides on a straight line.**

Construction:

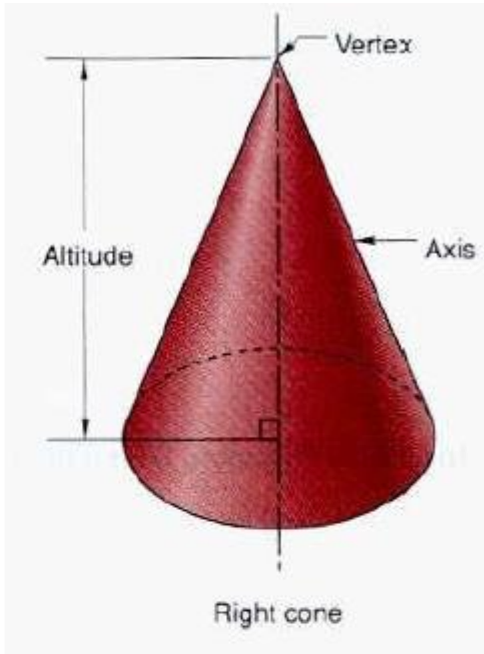
1. Draw the given straight line AB.
2. At B erect a perpendicular BC equal in length to AB.
3. Join AC and where it cuts the perpendicular bisector of AB, number the point 4.
4. Complete the square ABCD of which AC is the diagonal.
5. With radius AB and centre B describe arc AC as shown.
6. Where this arc cuts the vertical centre line numbers the point 6.
7. This is the centre of a circle inside which a hexagon of side AB can now be drawn.
8. Bisect the distance 4-6 on the vertical centre line.
9. Mark this bisection 5. This is the centre in which a regular pentagon of side AB can now be drawn.
10. On the vertical centre line step off from point 6 a distance equal in length to the distance 5-6. this is the centre of a circle in which a regular heptagon of side AB can now be drawn.
11. If further distances 5-6 are now stepped off along the vertical centre line and are numbered consecutively, each will be the centre of a circle in which a regular polygon can be inscribed with side of length AB and with a number of sides denoted by the number against the centre.

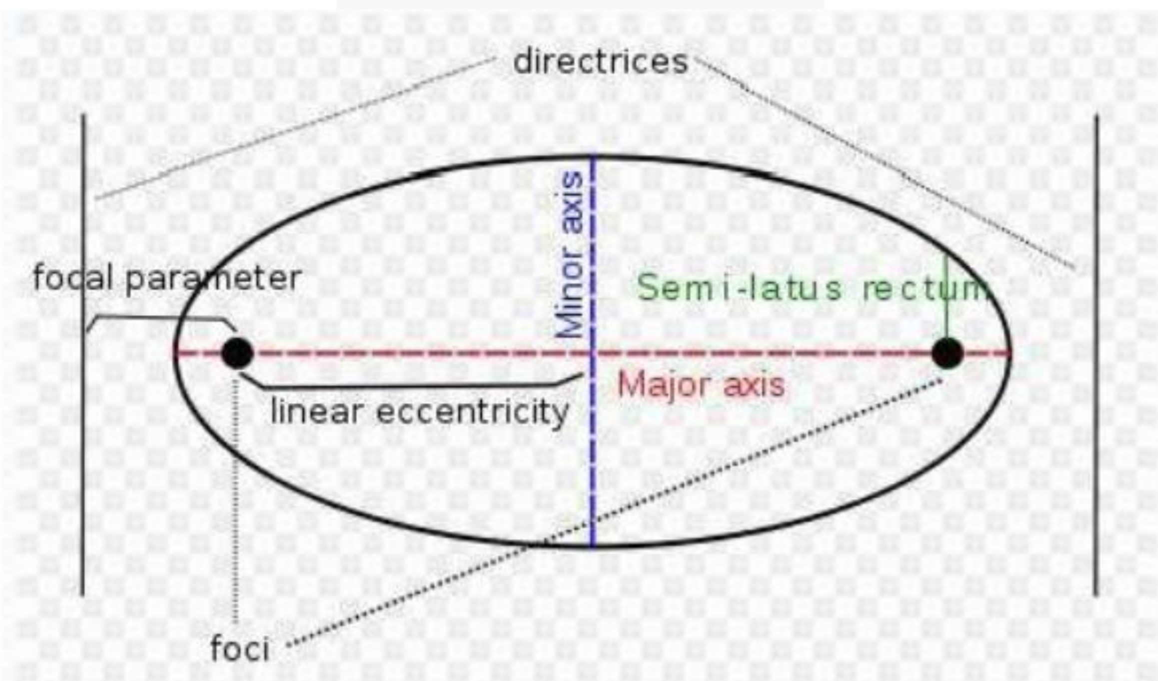


10
9
8
7
D
C
6
5
4
A
B

## CONIC SECTIONS

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

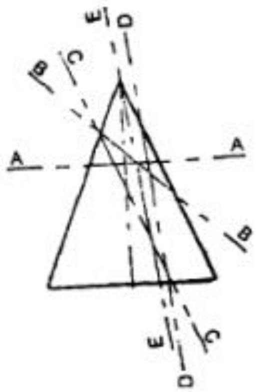


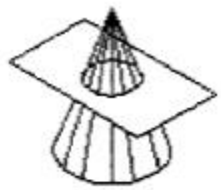



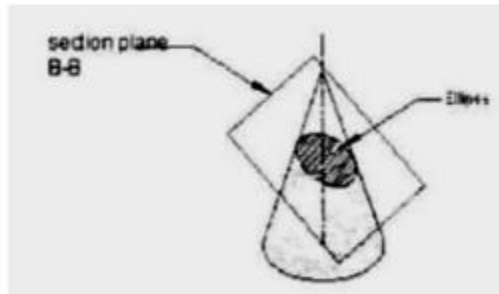

**Fixed point is called Focus**
**Fixed line is called Directrix**

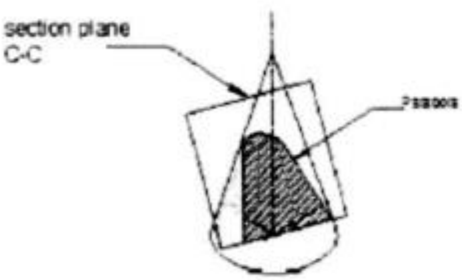
$$\text{Eccentrici ty} = \frac{\text{Distance of the point from the focus}}{\text{Distance of the point from the directric}}$$

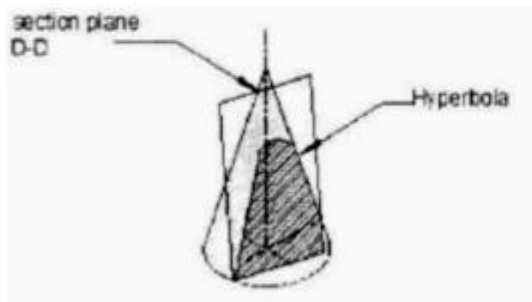
a) CIRCLE: b) ELLIPSE: c) PARABOLA: d) HYPERBOLA:






Eccentricity(e) :
a. If e=1, it is parabola
b. If e>1, it is hyperbola
c. If e<1, it is an ellipse
Where eccentricity e is the ratio of distance of the point from the focus to the distance of the point from the directrix.

# Cutting Planes

AA GIVES CIRCLE
BB " ELLIPSE
CC " PARABOLA
DD " HYPERBOLA
EE " RECTANGULAR-HYPERBOLA

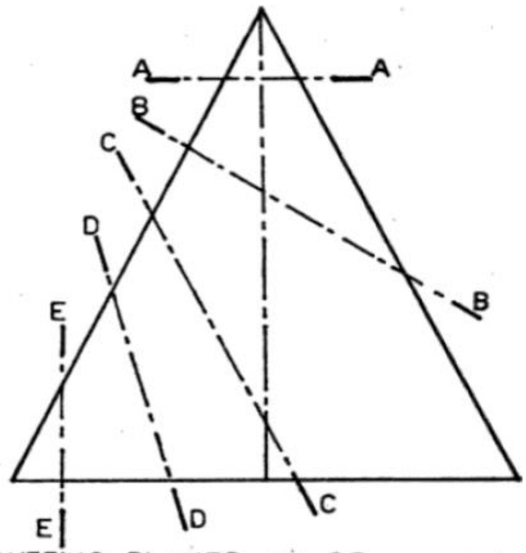
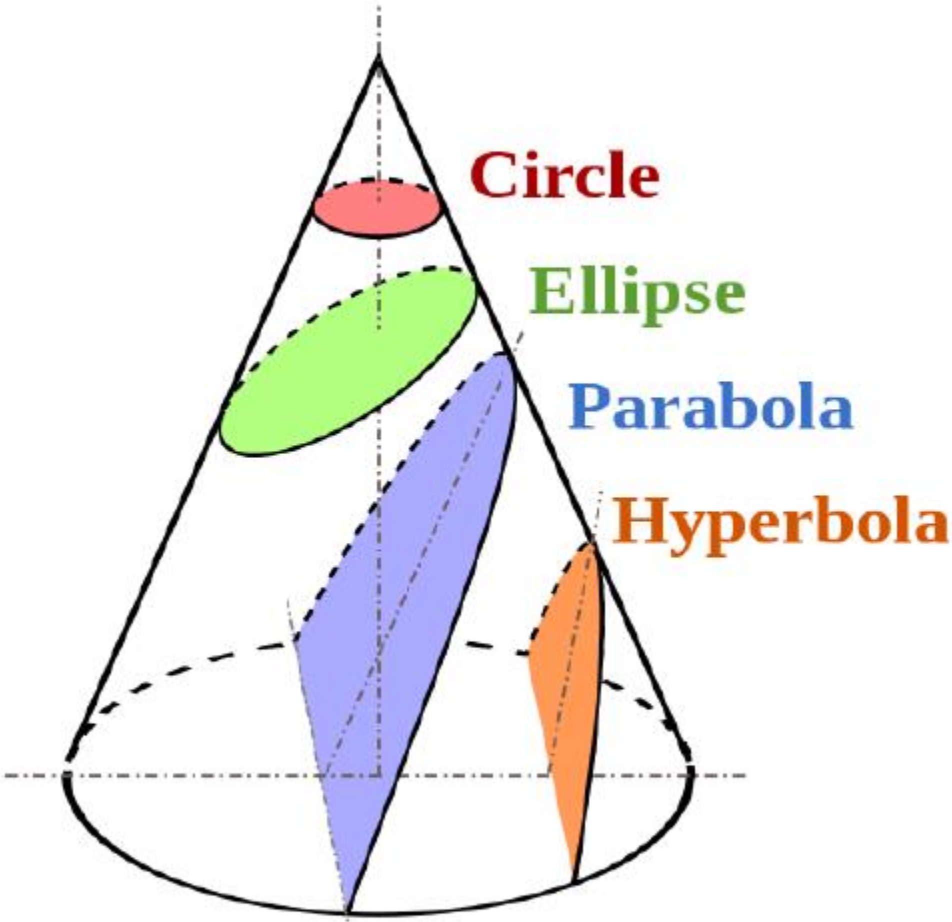



FIG.6.1

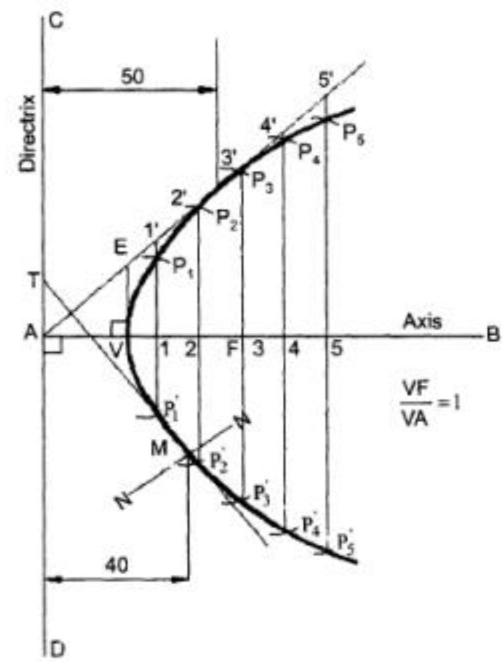
(b) CUTTING PLANES AA, BB, -----



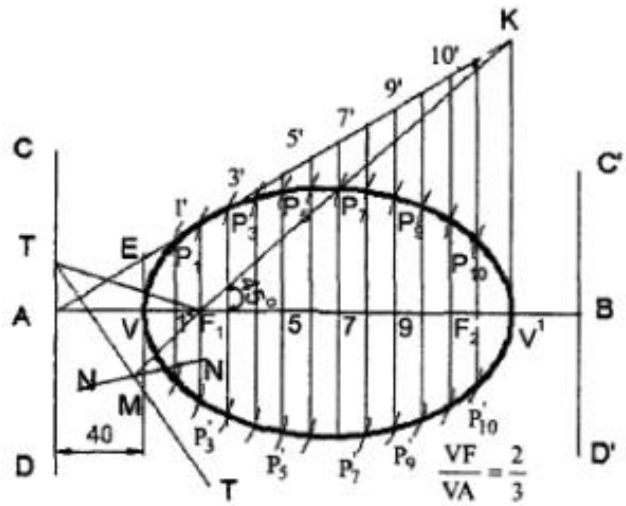
• **To draw a parabola with the distance of the focus from the directrix at 50mm (Eccentricity method).**

Construction:

1. Draw the axis AB and the directrix CD at right angles to it.
2. Mark the focus F on the axis at 50mm.
3. Locate the vertex V on AB such that AV = VF
4. Draw a line VE perpendicular to AB such that VE = VF
5. Join A, E and extend. Now, VE/VA = VF/VA = 1, the eccentricity.
6. Locate number of points 1, 2, 3, etc., to the right of V on the axis, which need not be equidistant.
7. Through the points 1, 2, 3, etc., draw lines perpendicular to the axis and to meet the line AE extended at 1',2',3' etc.
8. With centre F and radius 1-1', draw arcs intersecting the line through 1 at P1 and P`1
9. Similarly, locate the points P2, P`2, P3, P`3 etc., on either side of the axis. Join the points by smooth curve, forming the required parabola.




• **To draw an ellipse with the distance of the focus from the directrix at 50mm and eccentricity = 2/3 (Eccentricity method).**




Construction:
1. Draw any vertical line CD as directrix.
2. At any point A in it, draw the axis AB.
3. Mark a focus F on the axis such that AF1=50mm.
4. Divide AF1 in to 5 equal divisions.
5. Mark the vertex V on the third division-point from A.
6. Thus eccentricity e= VF1/VA = 2/3.
7. A scale may now be constructed on the axis which will directly give the distances in the required ratio.
8. At V, draw a perpendicular VE = VF1. Draw a line joining A and E.
9. Mark any point 1 on the axis and through it draw a perpendicular to meet AE produced at 1'.
10. With centre F and radius equal to 1-1', draw arcs to intersect a perpendicular through 1 at points P1 and P'1.
11. Similarly mark points 2, 3 etc. on the axis and obtain points P2 and P'2, P3 and P'3, etc.
12. Draw the ellipse through these points, it is a closed curve two foci and two directrices.

- **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 CD and the axis AB.
2. Mark the focus F on AB and 65mm from A.
3. Divide AF into 5 equal divisions and mark V the vertex, on the second division from A.
4. Draw a line VE perpendicular to AB such that VE=VF. Join A and E.
5. Mark any point 1 on the axis and through it, draw a perpendicular to meet AE produced at 1'.
6. With centre F and radius equal to 1-1', draw arcs intersecting the perpendicular through 1 at P1 and P'1.
7. Similarly mark a number of points 2, 3 etc and obtain points P2 and P'2, etc.