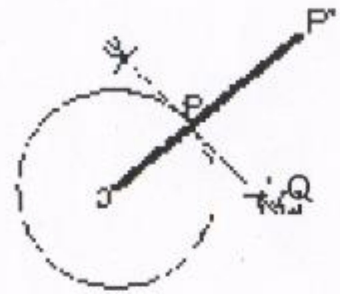
To draw a tangent to a circle construction (Fig. a and b)

(a) At any point P on the circle.

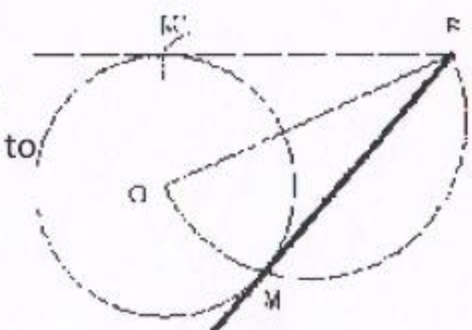
1. With 0 as centre, draw the given circle. P is any point on the circle at which tangent to be drawn (Fig .a)
2. Join 0 with P and produce it to p' so that OP = pp'
3. With 0 and p' as centres and a length greater than OP as radius, draw arcs intersecting each other at Q.
4. Draw a line through P and Q. This line is the required tangent that will be perpendicular to OP at P.



(a)

(b) From any point outside the circle.

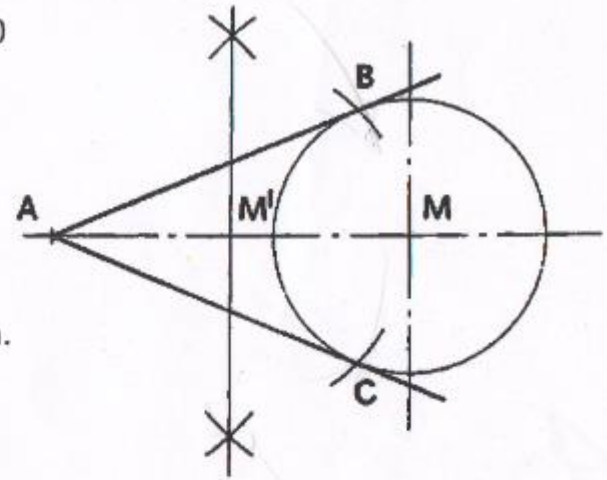
1. With 0 as centre, draw the given circle. P is the point outside the circle from which tangent is to be drawn to the circle (F ig. b).
2. Join 0 with P. With OP as diameter, draw a semi-circle intersecting the given circle at M.
3. Then, the line drawn through P and M is the required tangent.
4. If the semi-circle is drawn on the other side, it will cut the given circle at MI. Then the line through P and MI will also be a tangent to the circle from P.



(b)

1- Circular Arc Connections

a-Construct the tangents to a circle having a diameter of 40 mm!.The tangents have to pass through the common intersection A. The distance AM is 55 mm. Connect A with B and A with C. AB and AC are the tangents.



Solution:

1-Find the centre M.

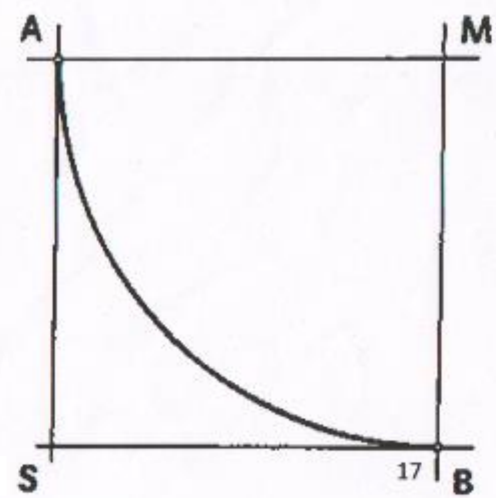
2-Draw circle with M as the centre and a radius of 20 mm. Find A (AM = 55 mm).

3-AM Bisect AM, thus obtaining M' (AM' = M'M).

4-Draw arcs with M' as the centre and AM' as the radius,

5-thus obtaining B and C.

b-The two legs of a right angle have to be connected by a circular arc with a radius of 30 mm.



Solution:

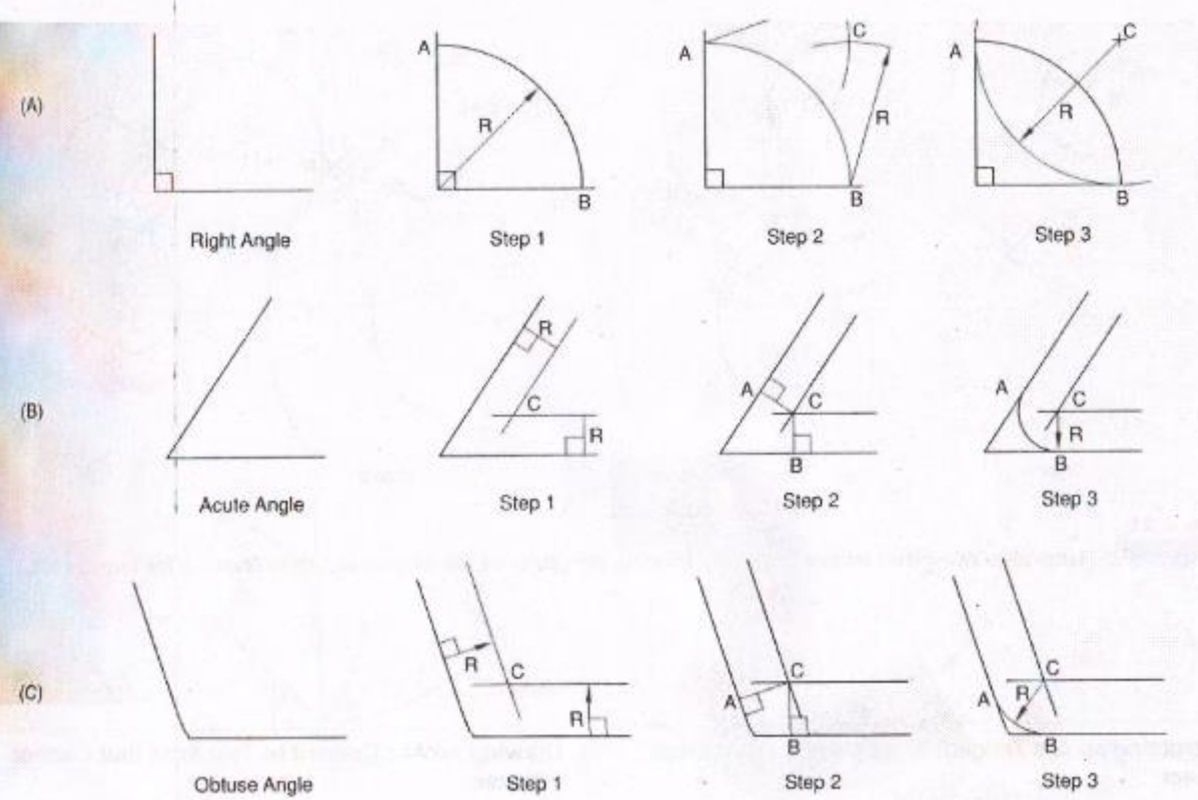
1-Draw a right angle, thus obtaining S.

2-Draw two parallels within the angle at a distance of 30 mm in any case.

3-The intersection of the parallels is the centre M.

4-The perpendiculars (AM and BM) are the points of connection.

Constructing arcs tangent to two lines



c-The two legs of an angle of 120° have to be connected by a circular arc with a radius of 36 mm.

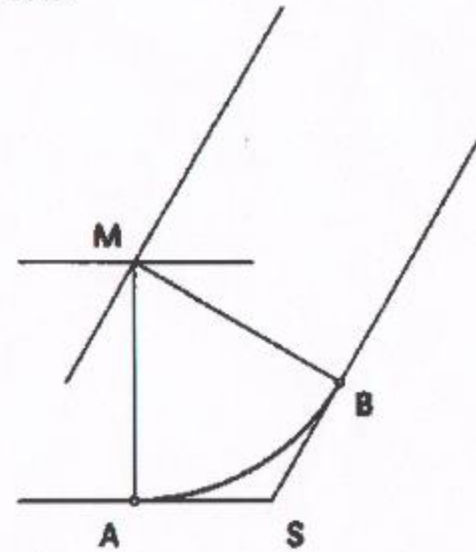
Solution:

1-Draw the angle (90° + 30°!), thus obtaining S.

2-Draw two parallels at a distance of 36 mm each, thus obtaining M.

3-Draw circle with M as the centre and a radius of 36mm.

4-The perpendiculars (AM and BM) are the points of connection.



d-Two adjacent circles have the following diameters:

d1 = 50 mm

d2 = 30 mm

The distance between their centres is 70 mm. The two circles have to be connected with a transition radius(Rtr) of 25 mm!

Solution:

1-Draw the two circles, thus obtaining M1 and M2.

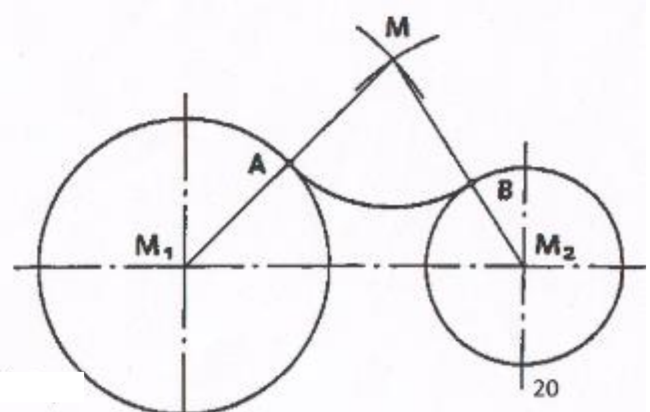
2-Draw a circular arc with M1 as the centre and the radius of R1 + Rtr (30 mm + 25 mm).

3-Draw a circular arc with M2 as the centre and the radius of R2 + Rtr (15 mm + 25 mm).

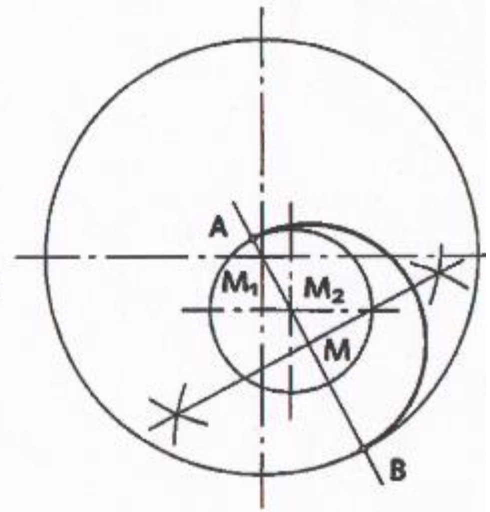
The intersection is M.

4-Connect M with M1 and M2, thus obtaining A and B.

A and B are the points of connection.

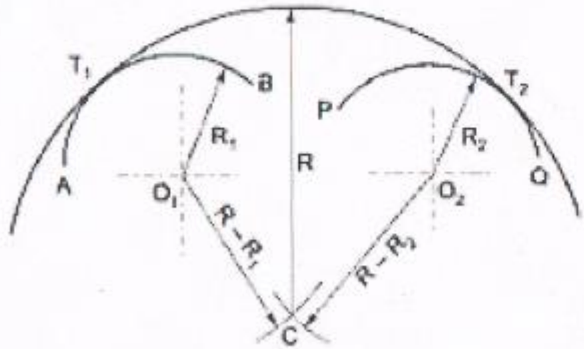


e-Two circles, an inner circle and an outer circle,
have to be connected by a circular arc. The circles have the following diameters:
outer circle = d1 = 60 mm, inner circle = d2 = 25 mm



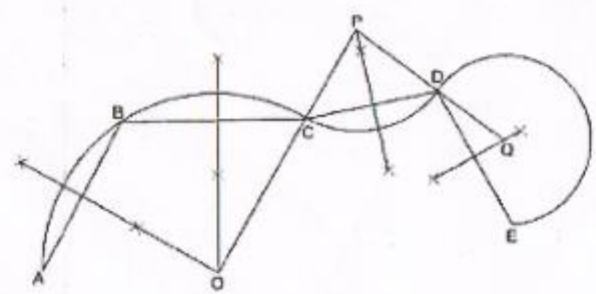
Solution:
1-Draw the two circles, thus obtaining M1 and M2.
2- Connect the centres and extend to the circles, thus obtaining A and B. Bisect AB, thus obtaining M as the centre for the circular arc.
3-Two adjacent circles have to be connected by a tangent. Their diameters are:
= 8d1 0 mm
d2 = 34 mm
The distance between the centres of the two circles is 85 mm.

Case : Draw an arc of given radius R touching two given arcs of of radius R_1 and R_2 (internally) [Fig. 1.]



1. Draw an arc with O_1 as centre and radius equal to $(R - R_1)$.
2. With O_2 as the centre and radius equal to $(R - R_2)$ draw an arc touching the previous arc at point C.
3. Draw the required arc, C as centre and radius equal to R.

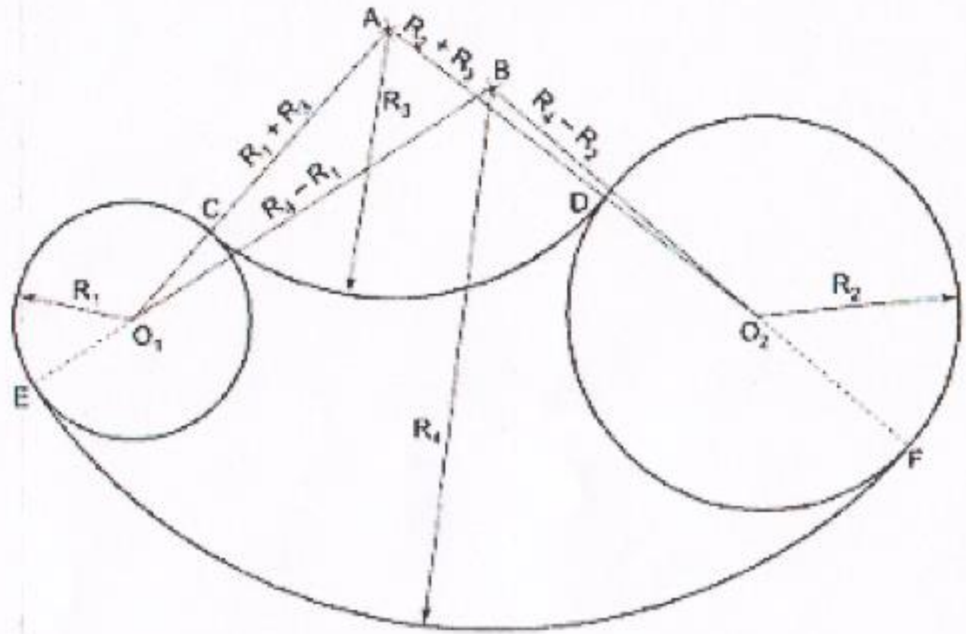
: To draw a continuous curve of circular arcs passing through any number of given points. (Fig.).



: Let A, B, C, D, and E be the location of the given points.

1. Join the points A with B, B with C, C with D and D with E, etc.
2. Draw perpendicular bisecter of lines AB and BC to intersect at O.
3. Draw an arc ABC, O as centre and radius equal to OA.
4. Draw a line through the points O and C.
5. Draw the perpendicular bisector of CD to intersect OC or OC produced at P.
6. Draw an arc CD, P as the centre and radius equal to PC.
7. Draw the line through the points P and D.
8. Draw the perpendicular bisector of DE to intersect PD produced at Q.
9. Draw an arc DE, Q as centre and radius equal to DQ.

To join two circles of centres O_1 and O_2 with two fillet arcs of radius R_3 and R_4 (Fig.).



1. Draw an arc with O_1 as centre and radius $(R_1 + R_3)$
2. With O_2 as centre and $(R_2 + R_3)$ radius draw an arc to intersect the previous arc at A, join O_1A and O_2A to intersect circles at C and D.
3. Draw the reauired fillet of radius R_3 with A as centre and R_3 radius. between C and D.
4. Draw an arc with O_1 as centre and $(R_4 - R_1)$ radius.
5. With O_2 as centre and $(R_4 - R_2)$ radius draw an arc to intersect the previous arc at B. Join O_1B and O_2B and produce to meet circles at E and F.
6. Draw the required fillet of radius R_4 with B as centre and R_4 radius, between E and F.

Fig. 1 Tangents to two circles

Solution:

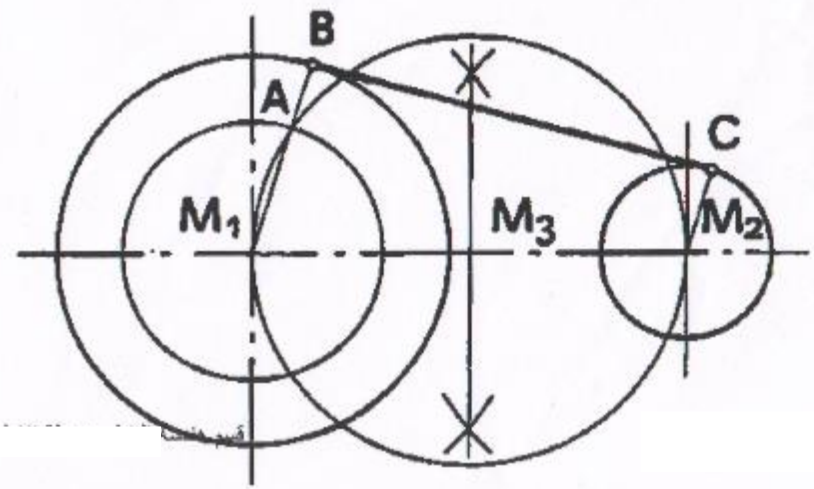
1-Draw the two circles, thus obtaining M1 and M2
(M1 M2 = 85 mm).

2-Draw circle with the centre M1 and the radius of R1 – R2 (40 mm – 17 mm).

3-Bisect M1 M2. Thus obtaining M3.

4-Draw a circle with M3 as the centre and M1M3 as the radius, thus obtaining A.

5-Extend M1A over A, thus obtaining B.



9-Ellipse

Given: Major axis AB, Minor axis CD

Solution: CONCENTRIC CIRCLEs METHOD

1-Draw the major axis and the minor axis, thus also obtaining, A, B, C, D and M.

2-Draw a circle with M as the centre and the radius equal to the major axis.

3-Draw a circle with M as the centre and the radius equal to the minor axis.

4-Draw any number of radii from M.

5-Mark off the points on the outer circle (F, H, K, N).

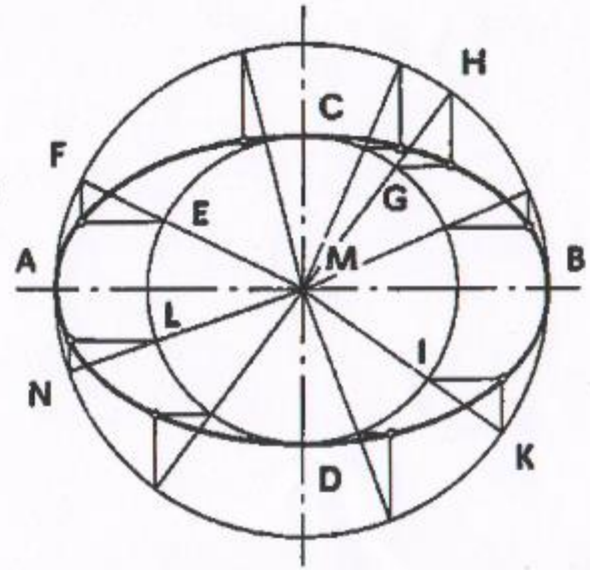
6-Mark off the points on the inner circle (E, G, I, L).

7-Draw further radii (without letter in the illustration).

8-Draw lines parallel to major axis through points provided by the intersections.

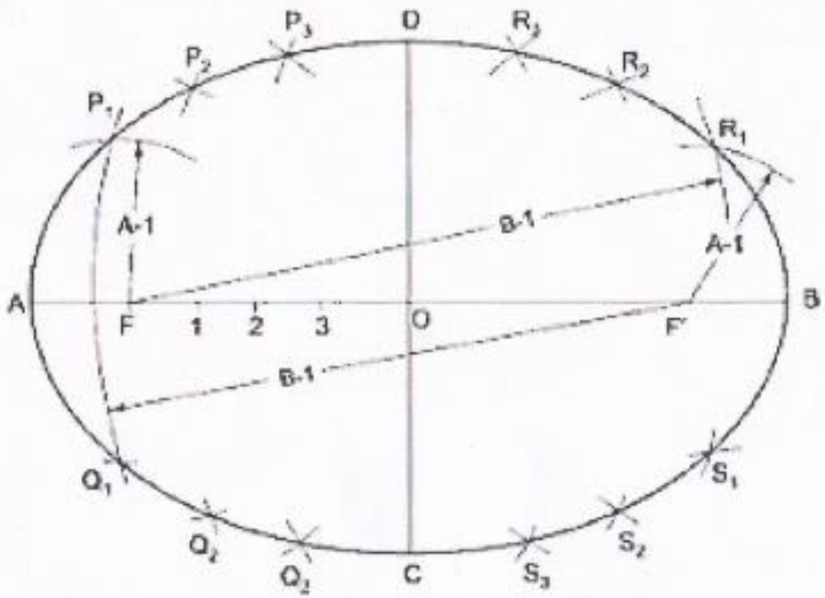
9-Draw lines parallel to the minor axis through points provided by intersections.

The intersections of the vertical and horizontal lines provide points of the ellipse.



CONCENTRIC CIRCLEs METHOD

Draw an ellipse with major axis equal to 120 mm and minor axis equal to 80 mm |Arcs of Circles Method] (Fig.).(INTERSECTING ARC METHOD)



INTERSECTING ARC METHOD

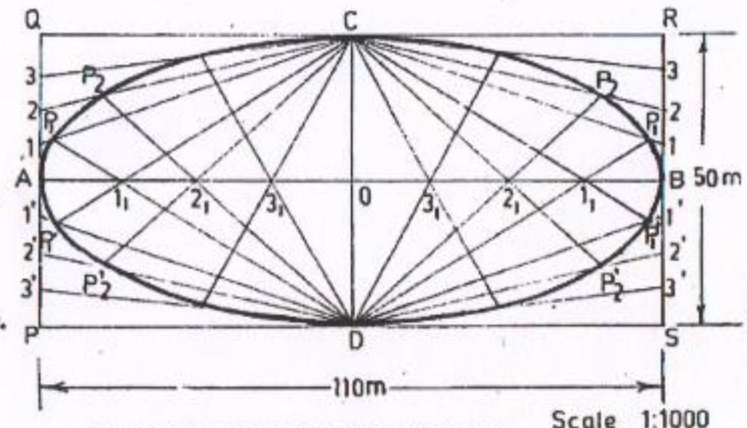
Solution:

1. Draw major axis AB = 120 mm and minor axis DC = 80 mm perpendicularly bisecting each other at O.
2. With centre C or D radius equal to AO, draw two arcs to intersect AB at F and F'.
3. Mark any number of points 1, 2, 3 ... etc. (say upto 10) at approximately equal intervals on AB in between F and F'.
4. F as centre and $A1$ as radius draw two arcs on either side of AB. F' as centre and $B1$ as radius draw two arcs to cut the previous arcs at P_1, Q_1, R_1, S_1.
5. Repeat the above and mark the points $P2, Q2, R2, S2$ and draw a smooth curve which is the required ellipse.

Rectangle Method (or) Oblong Method

(Fig.) A plot of ground is in the shape of a rect
110m x 50 m. Inscribe an elliptical lawn in it. Take a of 1 : 1000.

1. Draw the major axis AB = 110mm and minor a: CD = 50 mm. Both axes bisect each other at O.
2. Through A and B draw lines parallel to CD.
3. Through C and D draw lines parallel to AB and construct the rectangle PQRS. Now PS = AB and SR = CD.
4. Divide AQ and AP into any number of equal parts (say 4) and name the points as 1, 2, 3 and 1', 2', 3' respectively starting from A on AQ and AP.
5. Divide AO into same (4) number of equal parts, and name the points as 1_1, 2_1, 3_1 starting from A on AO.
6. Join 1. 2. 3 with C. Join $D1_1$ and extend it to intersect C1 at P_1.
7. Similarly extend $D2_1$ and $D3_1$ to intersect C2 and C3 at P_2 nd P_3 respectively. Join 1', 2', 3' with D.
8. Join $C1_1$ and extend it to intersect D1' at P_1'.
9. Similarly extend $C2_1$ and $C3_1$ to intersect D2'and D3' at P_2' and P_3' respectively.
10. Draw a smooth curve through C, P_3 ,P_2 ,P_1 , A, P_1' ,P_2' ,P_1' , D and obtain one half (left-half) of the ellipse.
11. Repeat the above and draw the right-half of the ellipse, which is symmetrical to the left-half.



RECTANGLE (OR) OBLONG METHOD

Construct an ellipse when a pair of Conjugate Diameters AB and CD are equal to 110 mm and 50 mm respectively. The angle between the conjugate diameters is 70°. (Fig.)

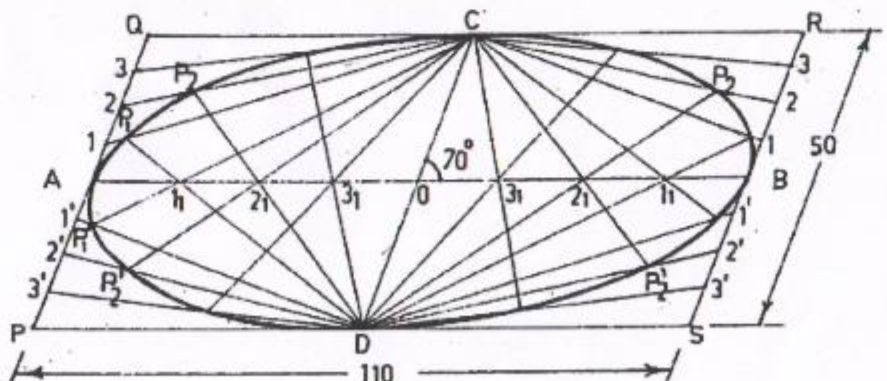
To construct the ellipse using conjugate diameters :

1. Draw a conjugate diameter AB = 110 mm and bisect it at O.

2. Angle between the conjugte diameters is 70°. Therefore draw another conjugate diameter CD through O such that the angle COB = 70°.

3. Through A and B draw lines parallel to CD. Through C and D draw lines parallel to AB and construct a parallelogram PQRS as shown.

4. Repeat the procedure given in step Nos. 4 to 11 in problem 10 and complete the construction of the ellipse inside the parallelogram PQRS.



PARALLELOGRAM METHOD

What are Conjugate Diameters ?

Conjugate Diameters are lines passing through the centre of ellipse and parallel to the tangents on the curve at the points of intersection of the other diameter with the ellipse.

To draw a parabola with the distance of the focus from the directrix at 50mm.

(Eccentricity method Fig.1).

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 11' through I at P I and P'I.
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.

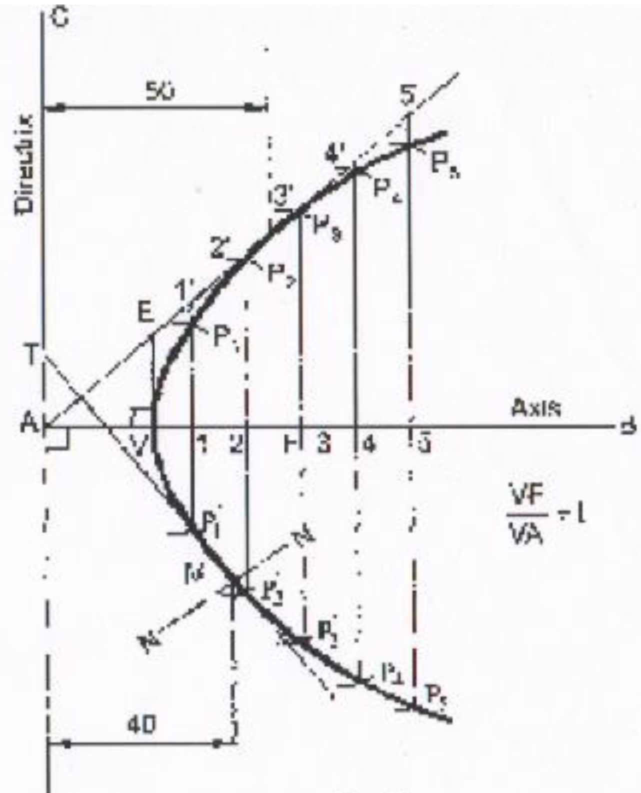


Fig.1

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

A ball thrown from the ground level reaches (Fig.) a maximum height of 5 m and travels a horizontal distance of 11 m from the point of projection. Trace the path of the ball (parabola).

1. The ball travels a horizontal distance of 11m. Take a scale of 1 : 100. Draw PS = 11 cm to represent the double ordinate. Bisect PS at O.

2. The ball reaches a maximum height of 5m. So from O erect vertical and mark the vertex V such that OV = 5cm. Now OV is the abscissa.

3. Construct the rectangle PQRS such that PS is the double ordinate and PQ = RS = VO (abscissa).

4. Divide PQ and RS into any number of (say 8) equal parts as 1, 2,... 8 and 1', 2',.. 8' respectively, starting from P on PQ and S on SR. Join 1, 2,... 8 and 1', 2',.... 8' with V.

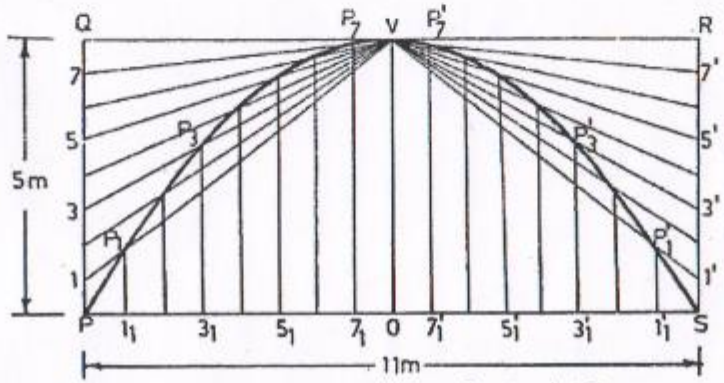
5. Divide PO and OS into 8 equal parts as 1_1, 2_1, . . . 8_1 and $1'_1$ $2'_1$, . . $8'_1$ respectively, starting from P on PO & from S on SO.

6. From 1_1 erect vertical to meet the line V1 at P_1.

7. Similarly from 2_1, . . . 8_1 erect verticals to meet the lines V2, . . . V8 at P_2, . . . P_8 respectively.

8. Also erect verticals from $1'_1$, $2'_1$ . . . $8'_1$ to meet the lines V1', V2' . . . V8' at P'_1, P'_2 . . . P'_8 respectively.

9. Join P, P_1, P_2, . . . P_7, V, P'_7, . . . P'_1 and S to represent the path of the ball (parabola).



PS - DOUBLE ORDINATE
OV - ABSCISSA

RECTANGLE METHOD

Scale = 1:100

Construct a parabola within a parallelogram (Fig.) of sides 110 mm x 50 mm. One of the included angle between the sides is 70°. **(Parallelogram Method)**

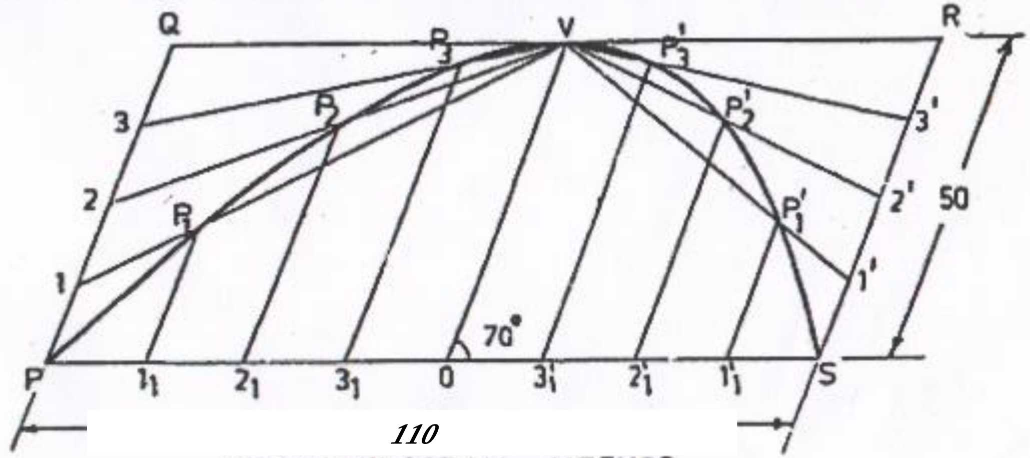
1. Construct the parallelogram PQRS (PS = 110mm and PQ = 50mm and angle QPS = 70°). Bisect PS at O and draw VO parallel to PQ.

2. Divide PQ and SR into any number of (4) equal parts as 1, 2, 3 and 1', 2', 3' respectively starting from P on PQ and from S on SR. Join V1, V2 & V3. Also join V1', V2' & V3'.

3. Divide PO and OS into 4 equal parts as 1_1, 2_1, 3_1 and $1'_1$, $2'_1$, $3'_1$ respectively starting from P on PO and from S on SO.

4. From 1_1 draw a line parallel to PQ to meet the line V1 at P_1. Similarly obtain the points P_2 and P_3.

5. Also from $1'_1$, $2'_1$, $3'_1$ draw lines parallel to RS to meet the lines V1', V2' and V3' at P'_1, P'_2 and P'_3 respectively and draw a smooth parabola.

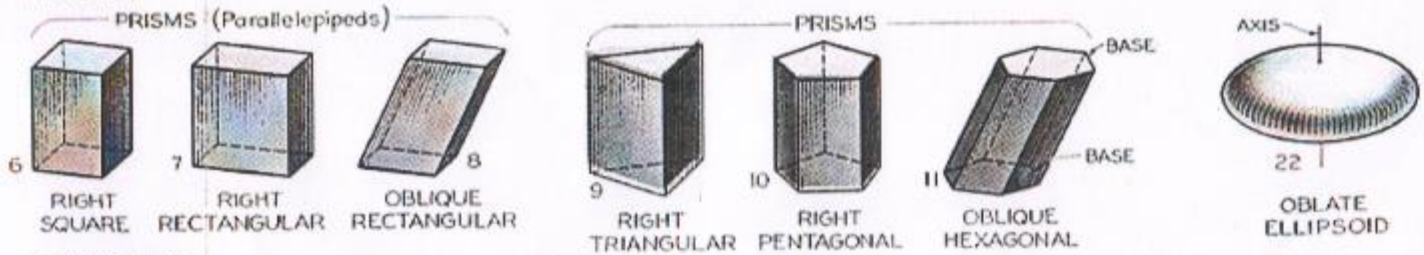


PARALLELOGRAM METHOD

THE 5 REGULAR SOLIDS

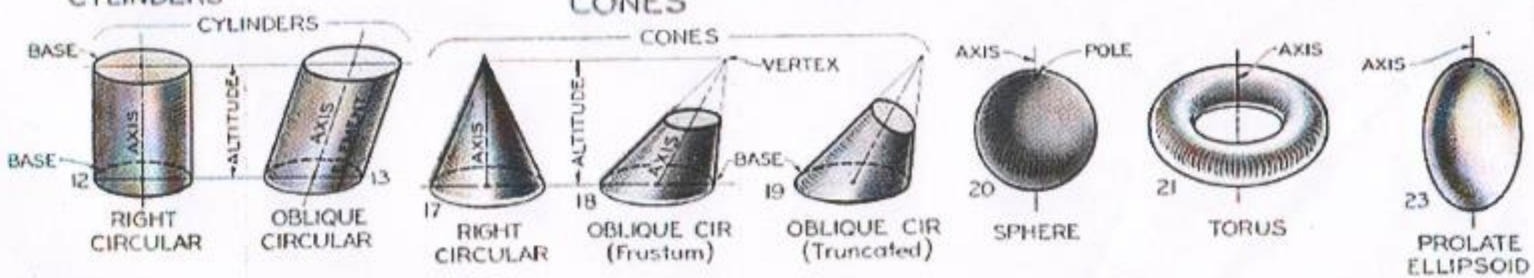
PYRAMIDS

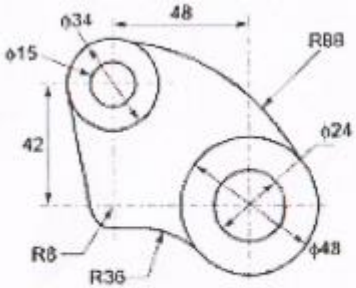
PRISMS



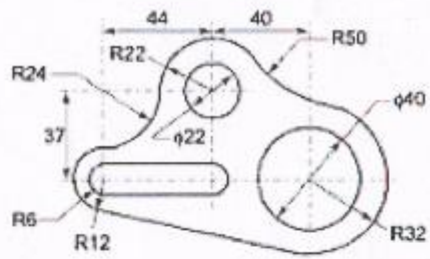
CYLINDERS

CONES

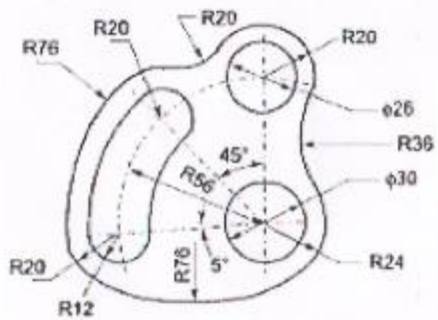




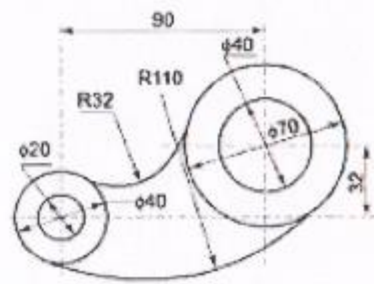
φ34
48
φ15
R88
42
φ24
φ48
R8
R36



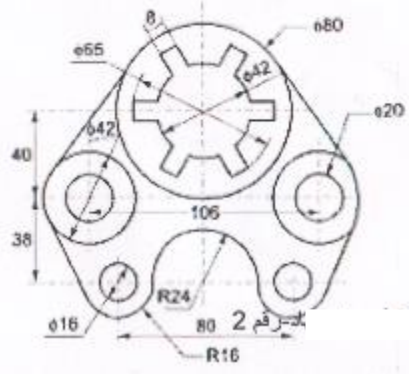
44
40
R50
R22
R24
φ40
37
φ22
R6
R12
R32



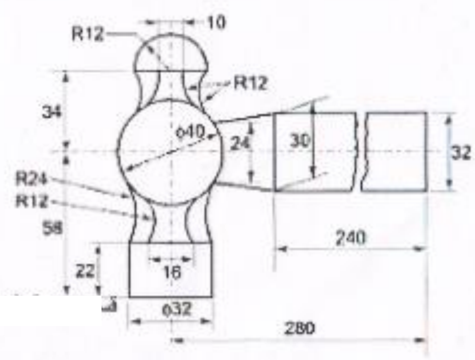
R20
R20
R76
R20
φ26
R36
45°
R56
φ30
R20
R76
5°
R24
R12



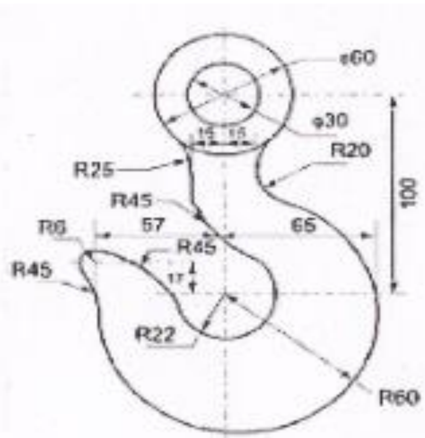
90
φ40
R110
R32
φ70
φ20
φ40
32

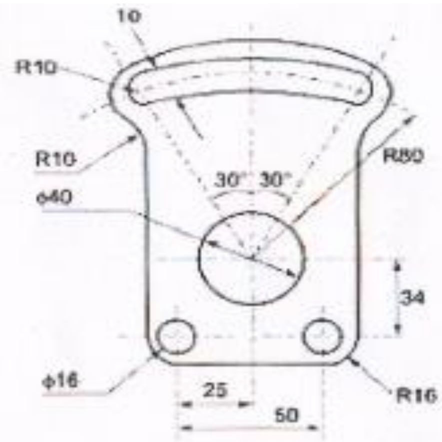


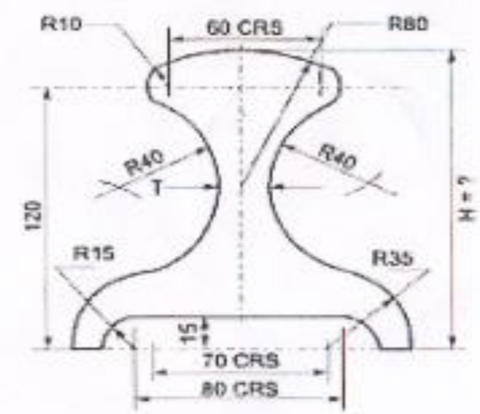
8
φ80
φ65
φ42
φ20
φ42
40
106
38
R24
φ16
80
R16



R12
10
R12
34
φ40
24
30
32
R24
R12
58
240
22
16
φ32
280


ø60
ø30
15 15
R25
R20
R45
100
R6
57
65
R45
R45
17
R22
R60


10
R10
R10
R80
30° 30°
ø40
34
ϕ16
25
50
R16


R10
60 CRS
R80
R40
R40
T
120
H = ?
R15
R35
15
70 CRS
80 CRS

Problem : *A stone is thrown from a building of 7 m high and at its highest flight it just crosses a plam tree 14 m high. Trace the path of the stone, if the distance between the building and the tree measured along the ground is 3.5 m.*

solution

1. Draw lines AB and OT, representing the building and Palm tree respectively, 3.5 m apart and above the ground level.
2. Locate C and D on the horizontal line through B such that CD=BC=3.5 and complete the rectangle BDEF.
3. Inscribe the parabola in the rectangle BDEF, by rectangular method.
4. Draw the path of the stone till it reaches the ground (H) extending the principle of rectangle method.