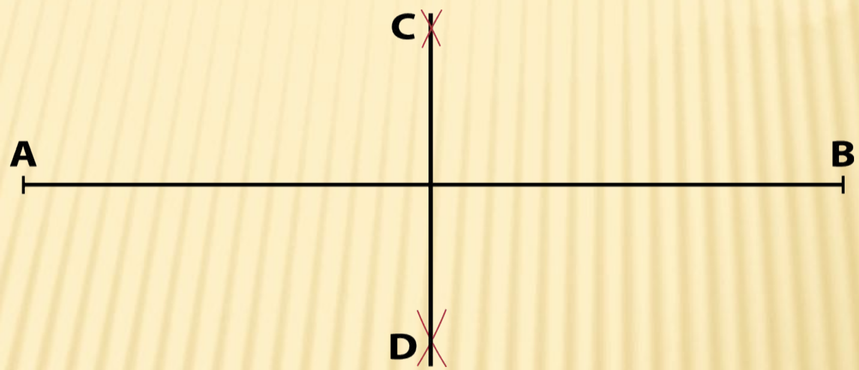
# CHAPTER 2: GEOMETRIC CONSTRUCTIONS

- **Geometric Nomenclature**
- **Elementary Construction Principles**
- **Polygon Construction**
- **Circular Construction**

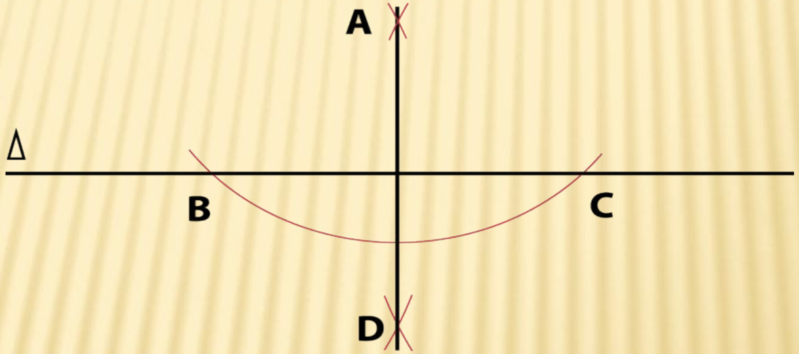
# Perpendicular Bisector of a Segment

With A and B as centers, draw two arcs of a circle with a radius greater than half of AB, intersecting at points C and D. Join C and D; this line CD is the perpendicular bisector of AB.



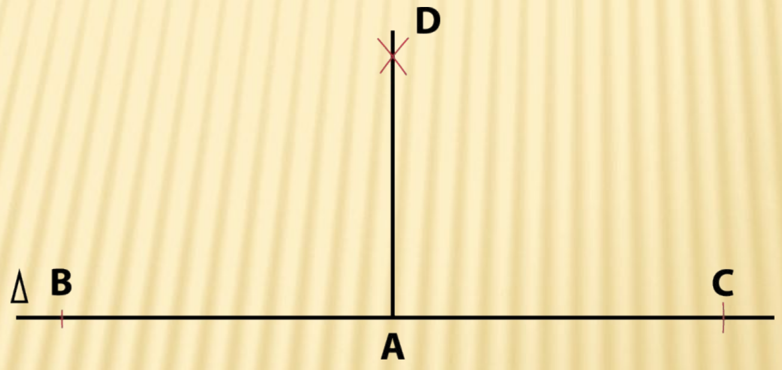
# Dropping a Perpendicular from a Point to a Line Δ

- With A as the center, draw an arc of a circle that intersects the line Δ at points B and C. With B and C as centers, draw two arcs of a circle with a radius greater than half of BC, intersecting at point D. Join A and D; this line AD is the desired perpendicular.



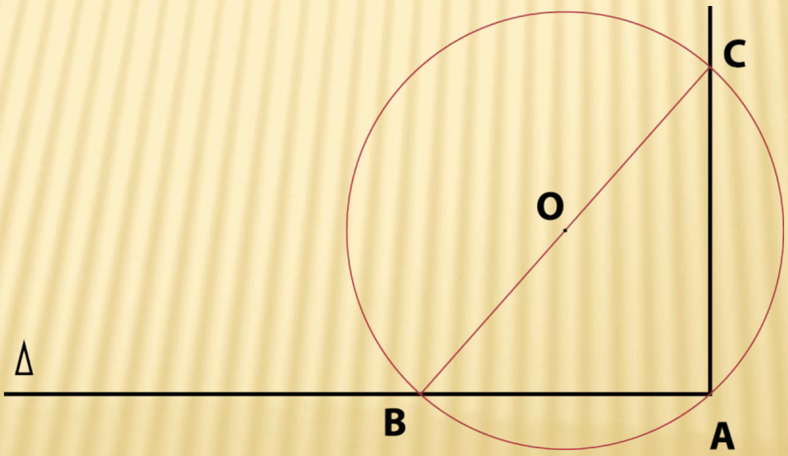
# Erecting a Perpendicular from a Point A on the line Δ.

With A as the center, draw two arcs of a circle with any arbitrary radius, which intersect the line Δ at points B and C. Keeping the same radius, and with B and C as centers, draw two arcs of a circle that intersect at point D. Join A and D; this line AD is the desired perpendicular.



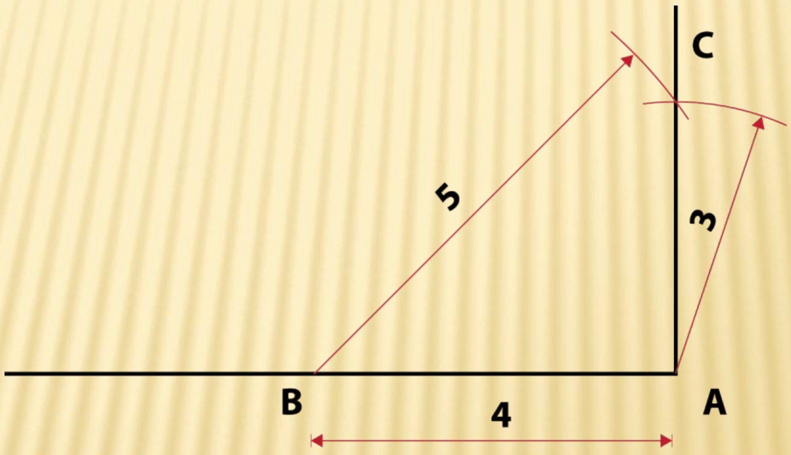
# Erecting a Perpendicular at the Endpoint of a Segment.

Take a point O, not on the line, whose projection lies on the segment. With O as the center and a radius of OA, draw a circle that intersects the line Δ at point B. Join B and O; this line intersects the circle at point C. Join C and A; this line CA is the perpendicular.



# Triangle Method (3-4-5) .

Draw AB = 4 units. From A, draw an arc with a radius of 3 units, and from B, draw an arc with a radius of 5 units. These arcs intersect at point C. Join C and A; this line CA is the desired perpendicular.



# Construction of Parallel Lines.

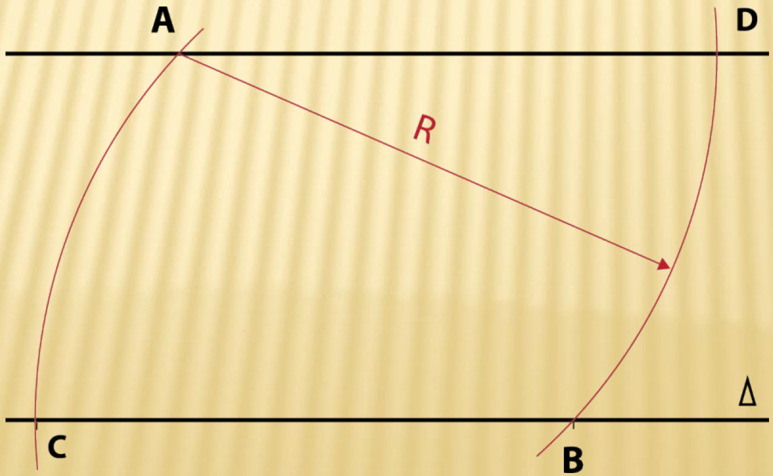
Drawing a line parallel to a line Δ at a given distance R. From any two points A and B on the line Δ, placed as far apart as possible, draw two arcs of a circle with a radius R. Draw the line that is tangent to both arcs.

This method is sufficiently accurate for common layouts, and its justification lies in its speed of execution.

# Drawing a line parallel to a line Δ passing through A.

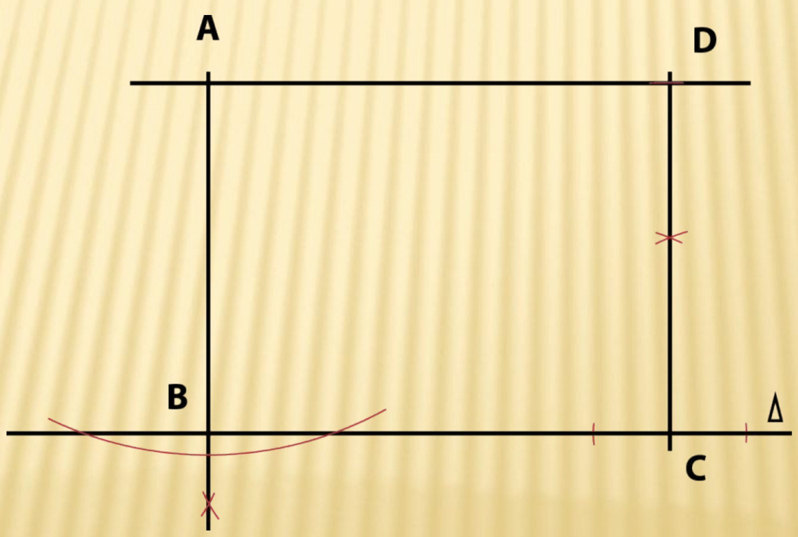
## First method

With A as the center, draw an arc of a circle with a radius R that intersects the line Δ at point B. With B as the center and the same radius R, draw an arc that passes through A and intersects the line Δ at point C. With C as the center, draw an arc with a radius equal to BA that intersects the first arc at point D. Join A and D; this line AD is the desired parallel (points A, B, C, D form a parallelogram).



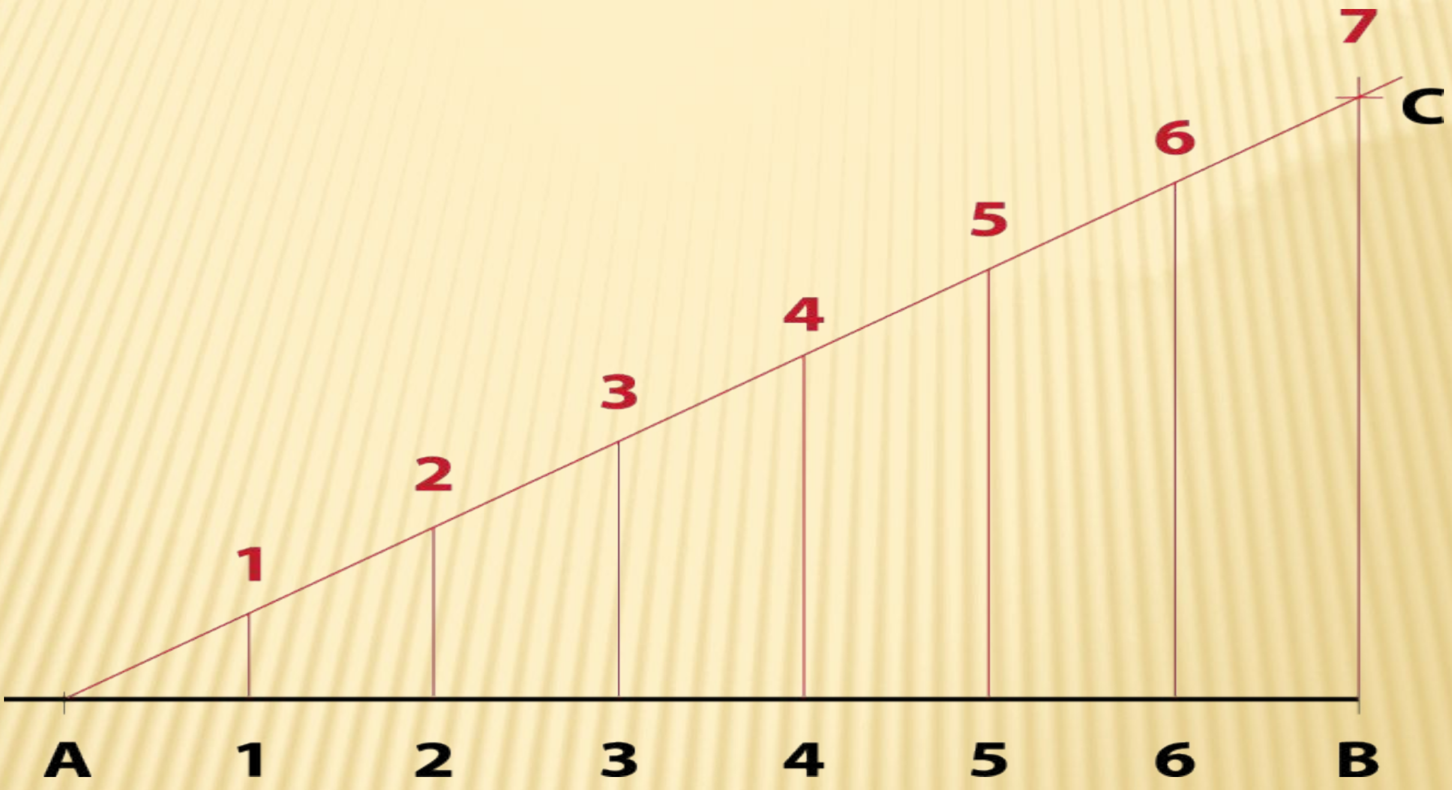
## Second method

- Drop the perpendicular AB from point A to the line Δ. From a point C on the line Δ, chosen as far away from A as possible, erect a perpendicular to the line Δ. Mark off the distance AB from point C along this perpendicular to define point D. Join A and D; this line is the parallel.



## Division of a segment into equal parts.

- Let AB be the segment to be divided into n equal parts:
- Erect a perpendicular to AB at point B.
- With A as the center, draw an arc of a circle with a radius R = n*x (where x is a length that is easily measurable, for example: 5, 10, or 20 mm). This arc intersects the perpendicular at point C.
- Divide the segment AC into n equal parts by marking off the cumulative values from point A: x, 2x, 3x, ..., n*x, using a graduated ruler.
- From the points thus defined, drop perpendiculars down to AB. These determine n equal segments on AB.
- In the accompanying example: n equals 7, x equals 10 mm.
- This construction is an application of the Thales' theorem (Intercept Theorem); it offers the advantage of allowing one to draw parallel lines using a set square and a drafting triangle.


7
C
6
5
4
3
2
1
A
1
2
3
4
5
6
B

- **Drawing regular convex inscribed polygons.**

- **Definition.**

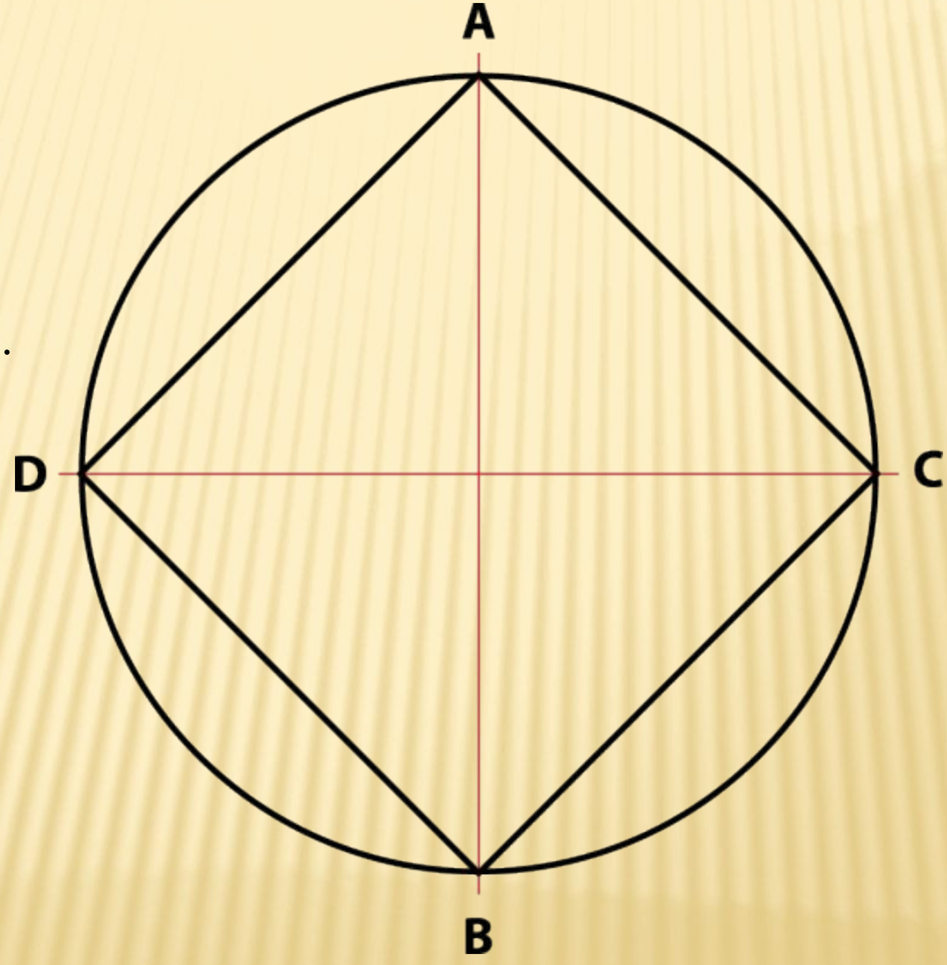
  A regular polygon has equal angles and equal sides, and it can be inscribed in a circumference of radius R.

  A regular polygon can always be constructed using the central angle $\alpha = 360°/n$ (where n = number of sides).

  The constructions to use for the most common regular polygons are indicated below.

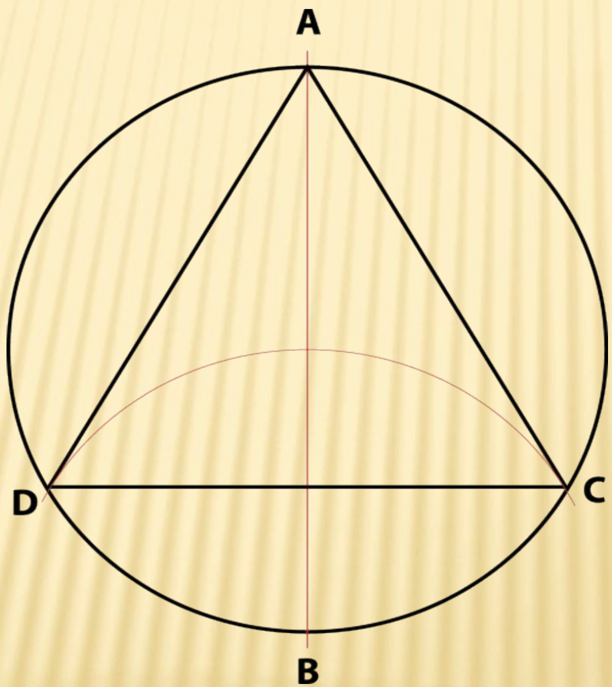
**Square**

Draw two perpendicular axes AB and CD. Connect AC, CB, BD, DA



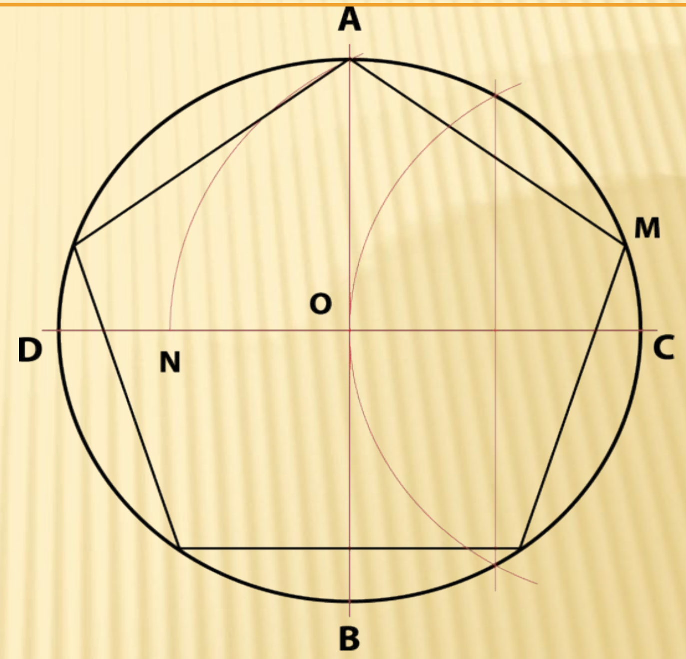
# Equilateral Triangle Draw a diameter AB.

With B as the center, draw arcs of a circle with radius R that intersect the circle at points D and C. Connect AC, CD, and DA.



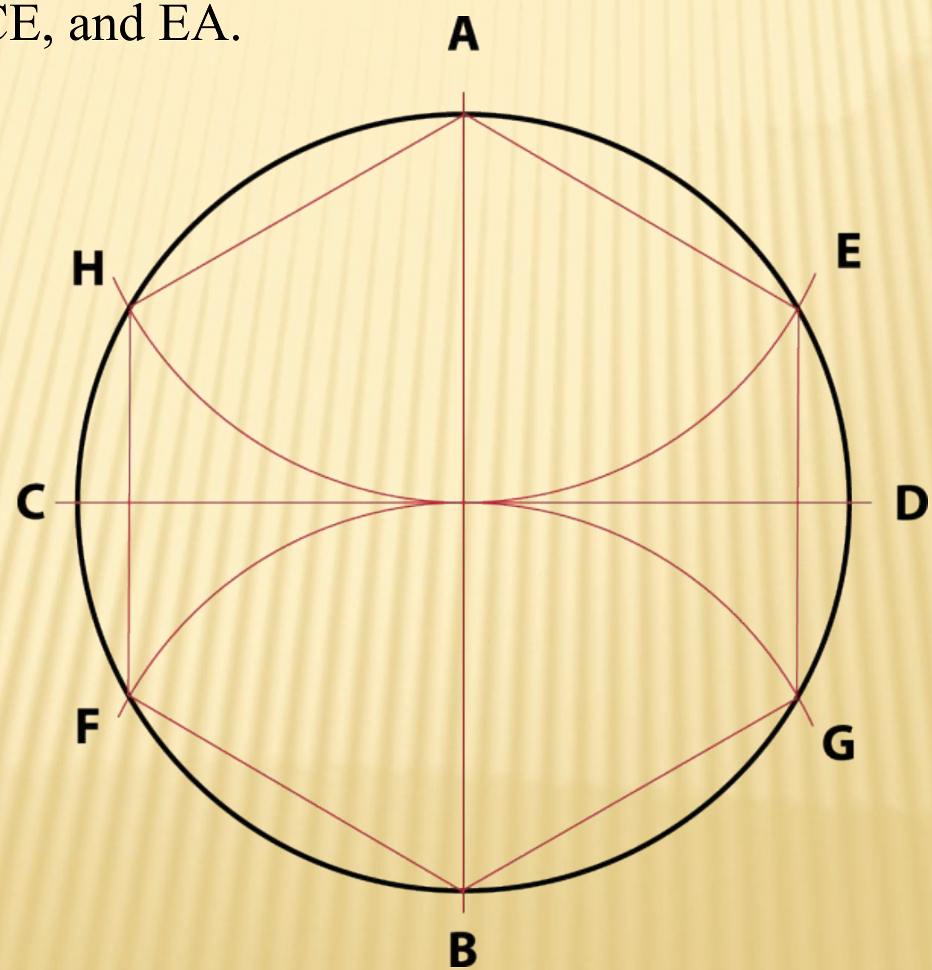
# Pentagon

Draw two perpendicular diameters AB and DC. Construct the perpendicular bisector of OC. Draw the arc of a circle with center I and radius IA, cutting DC at point N The segment AN represents the length of one side of the pentagon.



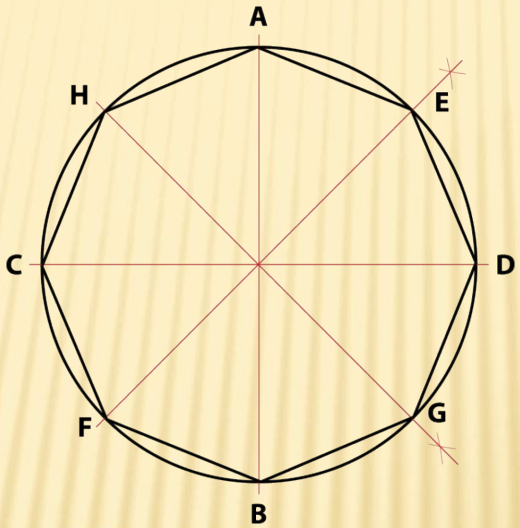
## Hexagon

Draw a diameter AB. With A and B as centers, draw arcs of a circle with radius R that intersect the circle at points C, D, E, and F. Connect BC, BD, DF, AF, CE, and EA.



# Octagon

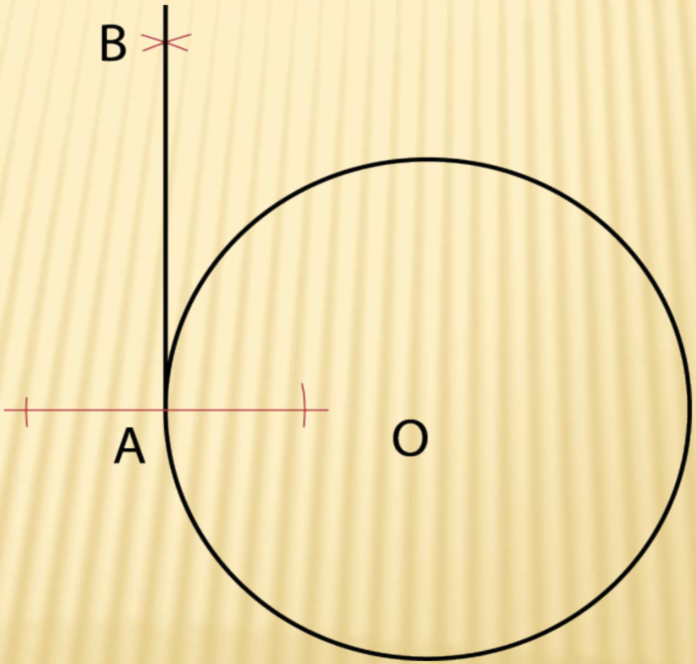
Draw two perpendicular diameters AB and CD. Draw the two bisectors of the right angles, EF and GH. Connect AH, HC, CF, FB, BG, GD, DE, and EA.



# Tangents and Connections.

## Tangents.

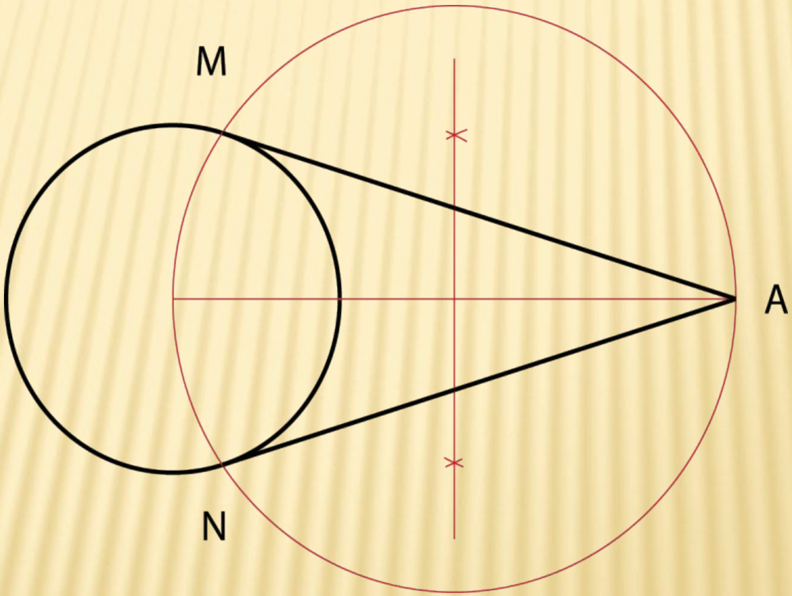
Tangent at a point on a circle. Draw OA, then construct the perpendicular line AB at point A to OA. AB is the tangent.



# Tangent passing through an external point.

**Draw the perpendicular bisector of OA.**

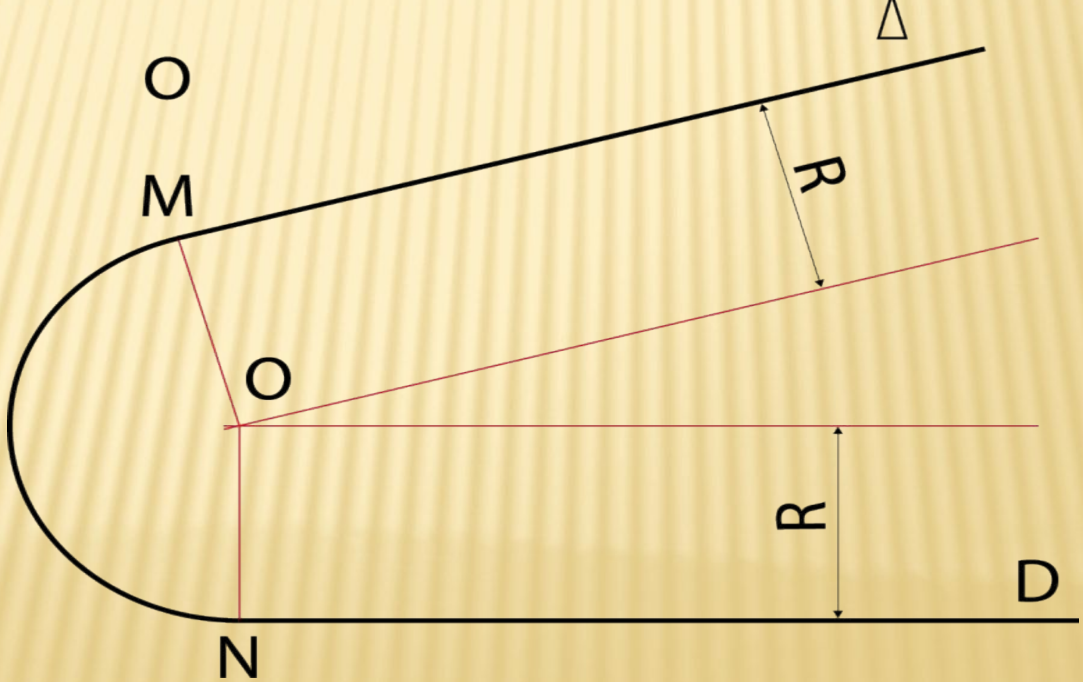
Draw the circle with center O and radius OA, which intersects the circle at the points of tangency M and N. Connect AM and AN.



## Connections

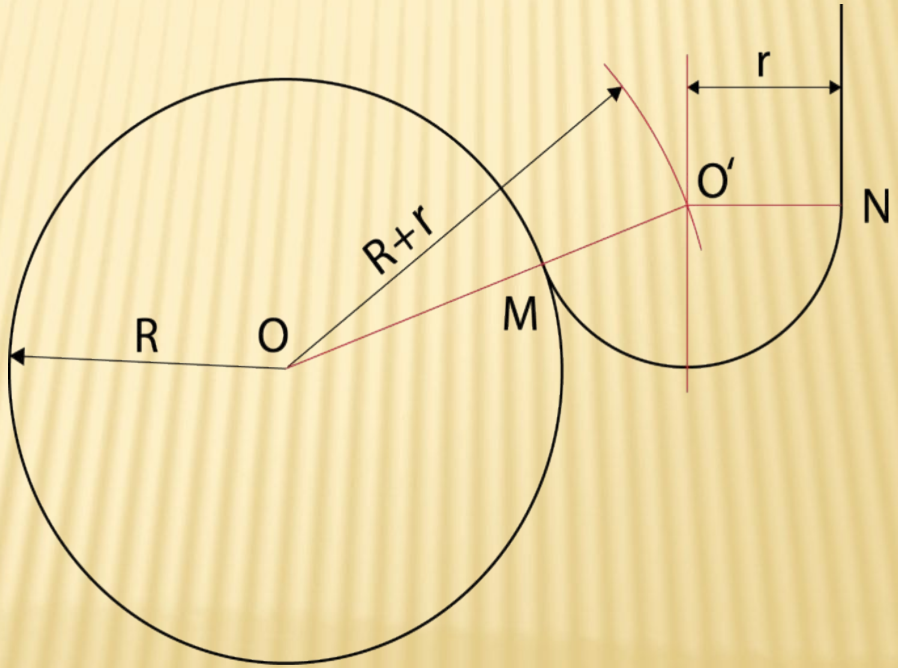
## Connecting Two Lines

Draw two lines parallel to the given lines Δ and D, each at a distance R from them. These parallels intersect at point O. From point O, drop perpendiculars to lines D and Δ, meeting them at points M and N respectively. Draw the circular arc MN with center O and radius R.



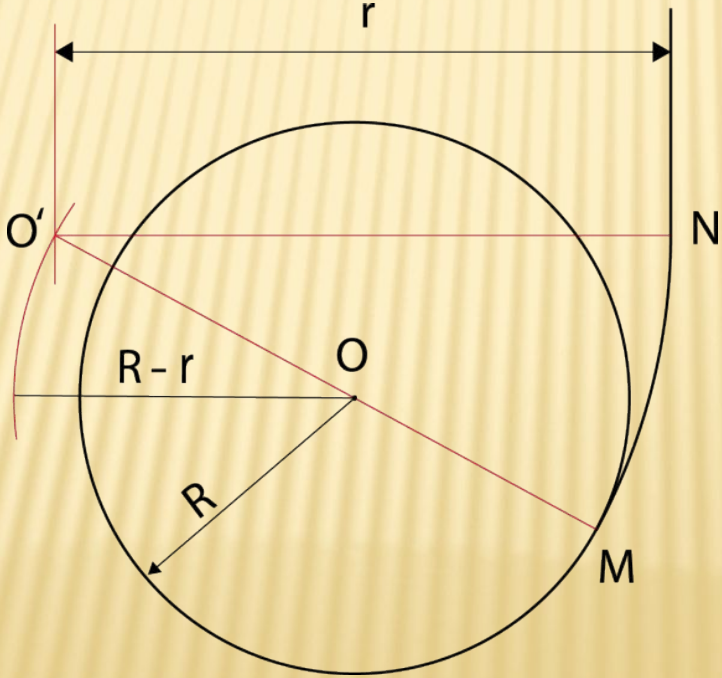
# Connecting a Line and a Circle (Externally)

Draw a line parallel to Δ at a distance r, and a circle with center O and radius (r + R). These intersect at point O'. Draw line OO', which intersects the circle at point M. From point O', drop a perpendicular to line Δ. Draw the circular arc MN with center O' and radius r.



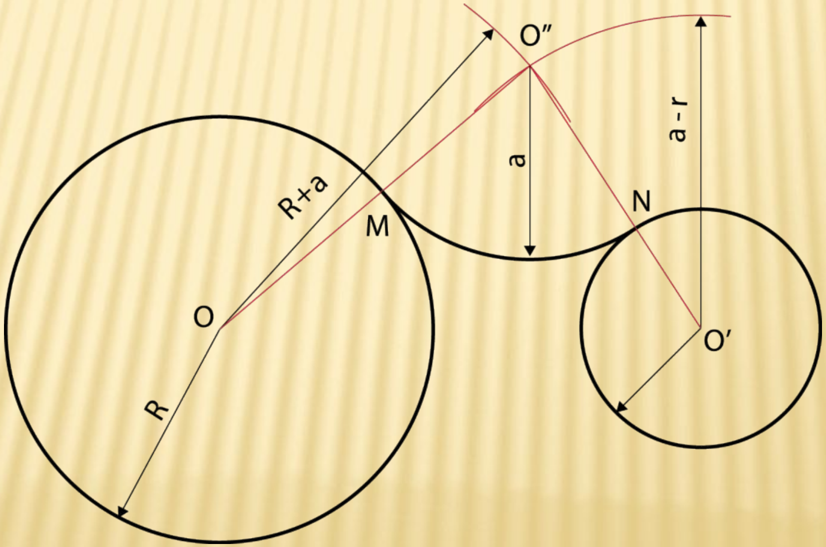
# Connecting a Line and a Circle (Internally)

Draw a line parallel to Δ at a distance r. Draw a circle with center O and radius (R - r). This circle intersects the line parallel to Δ at point O'. From O', drop a perpendicular to line Δ, and draw line OO', which intersects the original circle at point M. With O' as the center and a radius of r, draw the connecting arc MN.



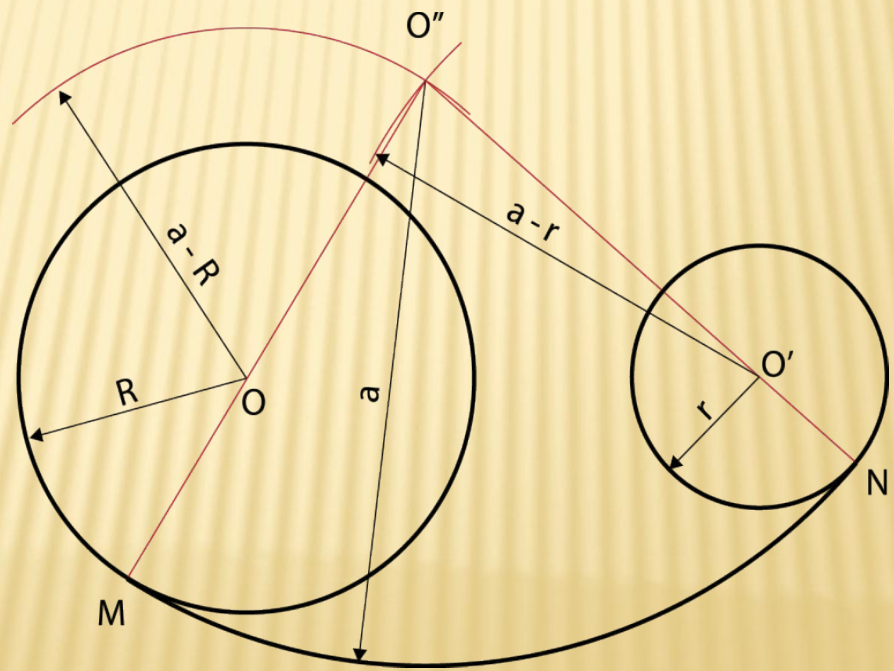
# Connecting Two Circles (Externally)

Draw a circle with center O and radius (R + a), and another circle with center O' and radius (r + a). These circles intersect at point O''. Draw lines OO'' and O'O'', which intersect the original circles at points M and N respectively. Draw the connecting arc MN from the circle with center O''.



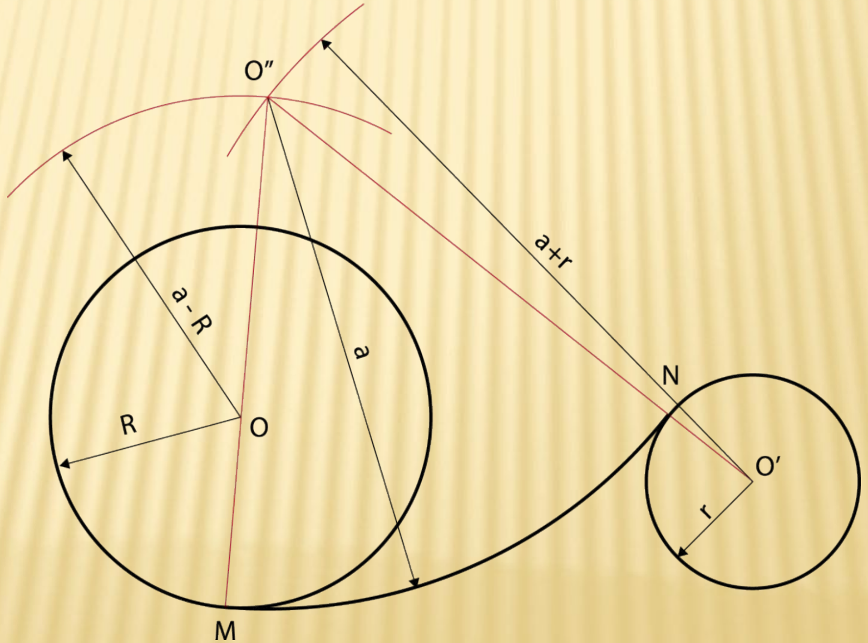
# Connecting Two Circles (Internally)

Draw two circles: one with center O and radius (a - R), and the other with center O' and radius (a - r). These circles intersect at point O''. Draw lines O''O and O''O', which intersect the original circles at points M and N respectively. Using O'' as the center, draw the connecting arc MN.



# Connecting Two Circles (Internally to One and Externally to the Other)

Draw two circles: one with center O and radius (a - R), and the other with center O' and radius (r + a). These circles intersect at point O". Draw lines O"O and O"O', which intersect the original circles at points M and N respectively. Draw the connecting arc MN with center O".



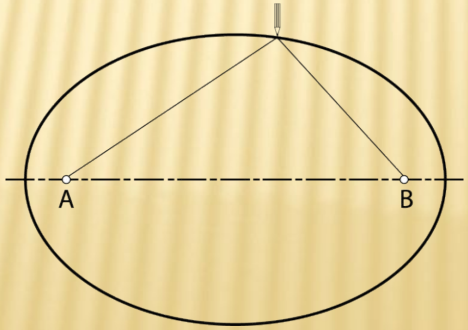
# Common Curves. The Ellipse.

It is the set of points where the sum of the distances to two fixed points, called foci, is constant. An ellipse is defined by the dimensions of its axes.

**The "Gardener's Method": (fig.)**

This method is very convenient for obtaining a large-scale ellipse without complex constructions. To do this:

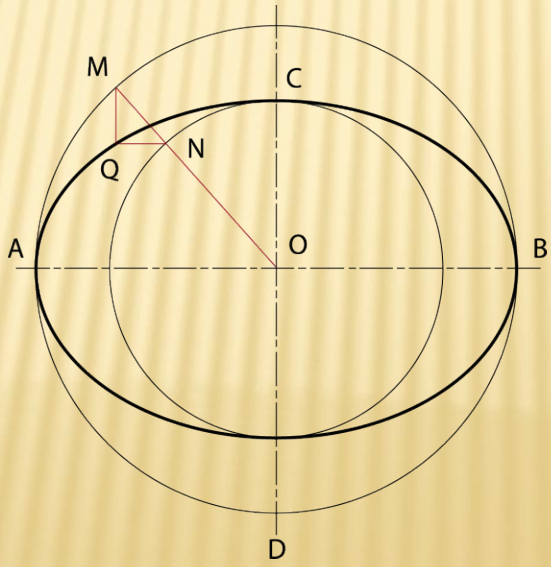
Secure a cord at points A and B (the foci). The length of the cord should be determined based on the desired dimensions. Keeping the cord taut, trace the curve on the ground.



# Circle Method: (fig.)

Draw two circles from center O, with diameters corresponding to the major axis and the minor axis of the desired ellipse, respectively. Draw a radius that intersects the larger circle at point M and the smaller circle at point N. Through point M, draw a line parallel to the minor axis; through point N, draw a line parallel to the major axis. These two lines intersect at point I, which is a point on the ellipse.

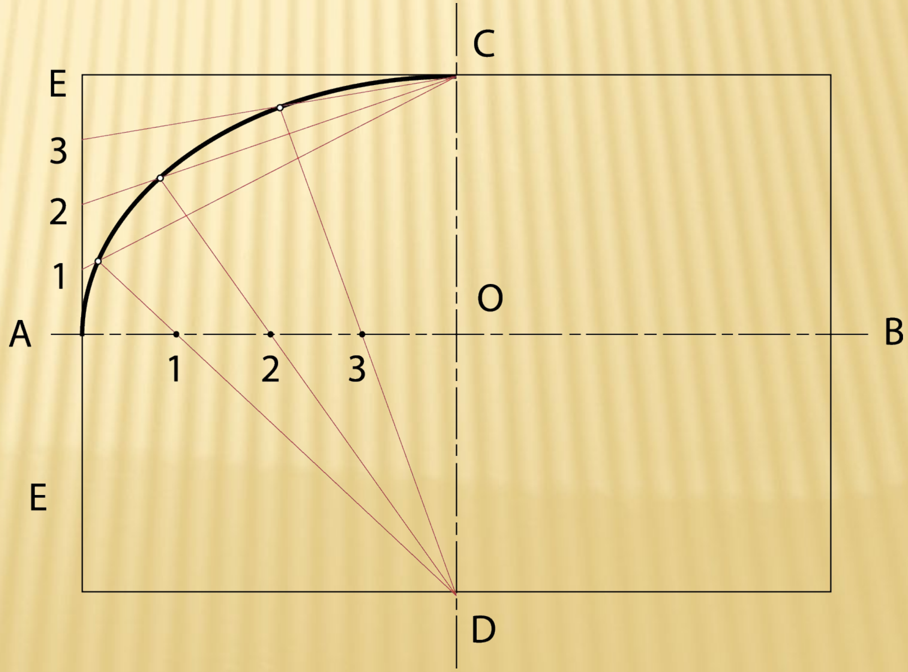
Repeat this process as many times as necessary to achieve the desired accuracy.



# Rectangle Method: (fig.)

Draw a rectangle whose sides are equal to the lengths of the major and minor axes of the ellipse.

Divide OA and AE into the same number of equal parts (four in the example). Connect the divisions on AE to point C, and the divisions on OA to point D. The intersections of the segments with the same numbering are points on the ellipse. Connect the points thus obtained.



**Exercise:**

Draw the shape indicated in the figure below at a 1:1 scale using connection techniques.

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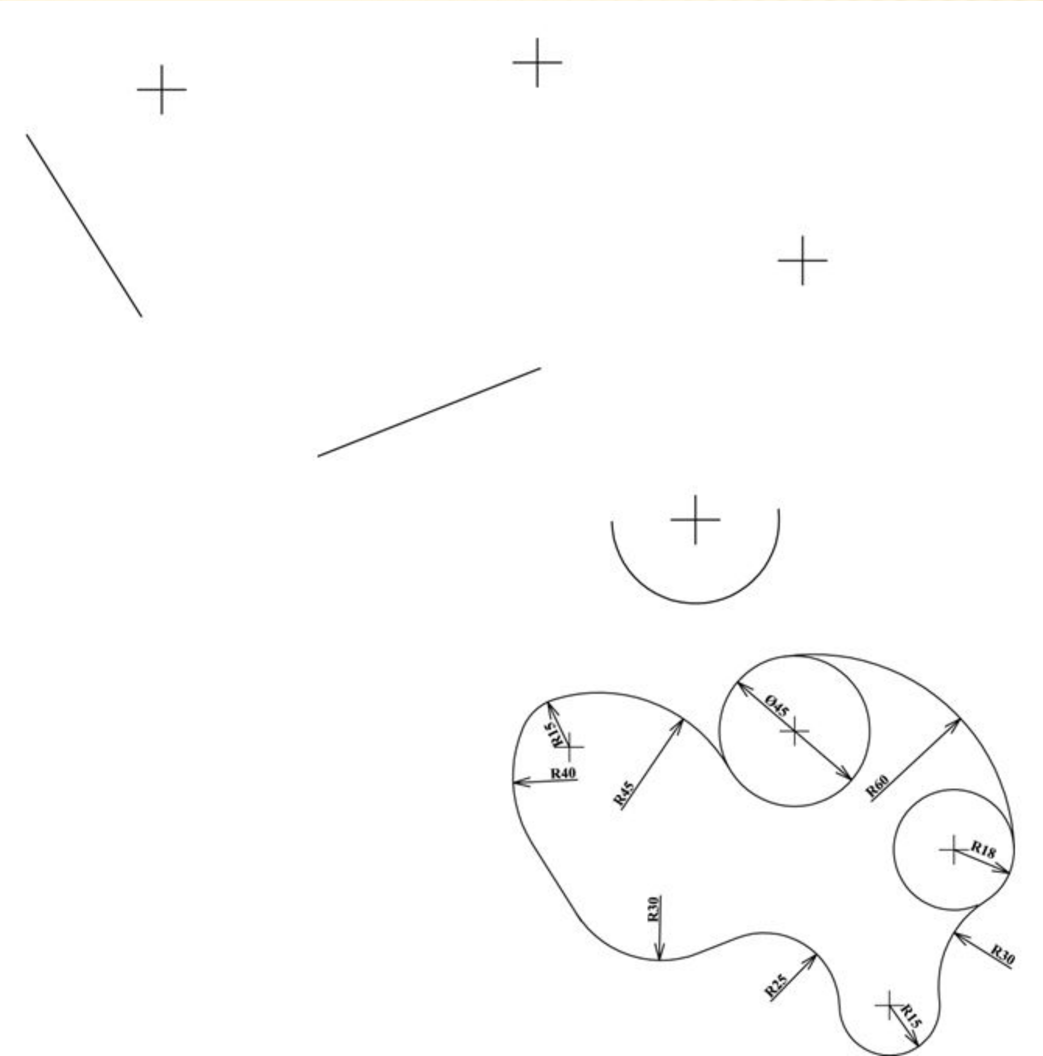
Draw the shape indicated in the figure below at a 1:1 scale using connection techniques.



# Good luck with your exercise!