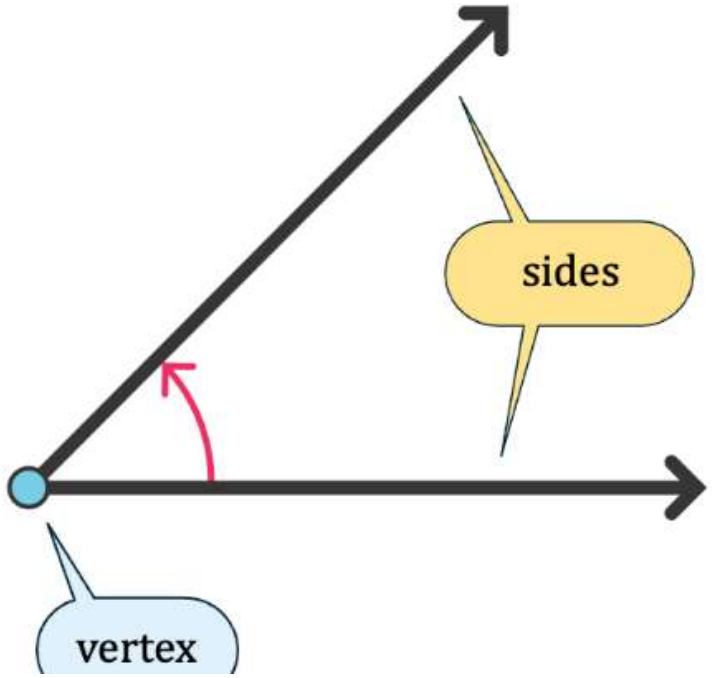
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TRADE: Engineering Drawing and Draughtsman (Mechanical & Civil)

UNIT- II Geometrical Figures, Special Curves, Free Hand Sketching and Scales

Angles:

- In engineering graphics, an angle is the geometric figure formed by two lines sharing a common endpoint called the vertex.
- It represents the measure of the "opening" between these two lines and is typically measured in degrees or radians.
- Angles are fundamental for defining the shape, orientation, and relationships between objects in engineering drawings.



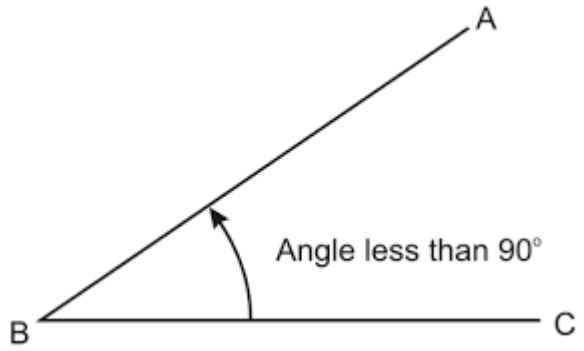
Types of Angles:

Acute Angle (< 90°):

- An **acute angle** is an angle that measures **less than 90 degrees**.

Key Points:

- It is **smaller than a right angle**.
- It always looks **sharp or narrow**.
- Range: **0° < Acute angle < 90°**

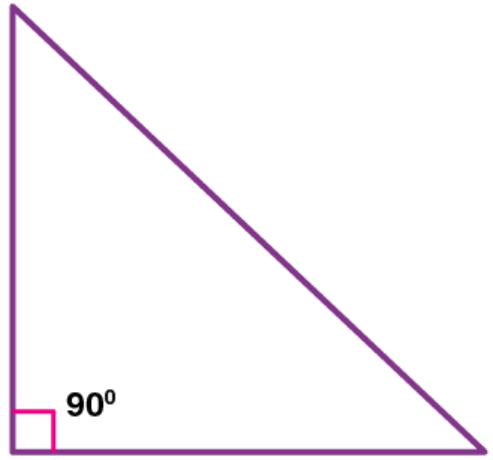


Right angle (= 90°):

- A **right angle** is an angle that measures **exactly 90 degrees**.

Key Points:

- It forms a **perfect "L" shape**.
- Represented with a **small square symbol** at the vertex.
- It **divides a straight angle (180°)** exactly in half.

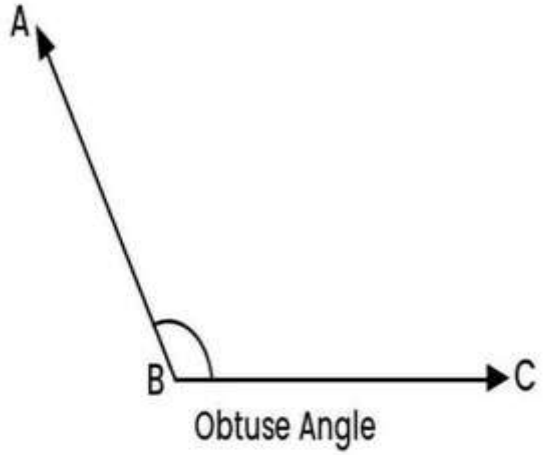


Obtuse angle (90°–180°):

- An **obtuse angle** is an angle that measures **more than 90 degrees but less than 180 degrees**.

Key Points:

- It is **wider than a right angle**.
- It appears as an **open or wide** angle.
- Range: **90° < Obtuse angle < 180°**

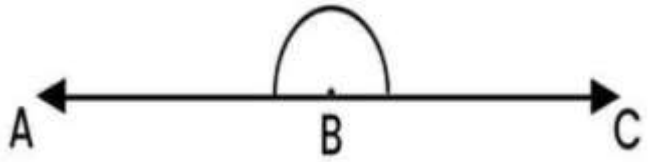


Straight Angle (= 180°):

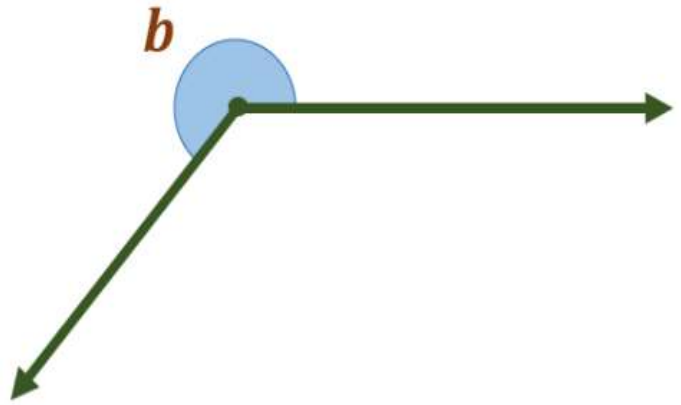
- A **straight angle** is an angle that measures **exactly 180 degrees**.

Key Points:

- It forms a **straight line**.
- The angle looks like a **flat, straight path**.
- It shows that the two rays (or arms) **point in exactly opposite directions**.



Reflex angle (> 180°)

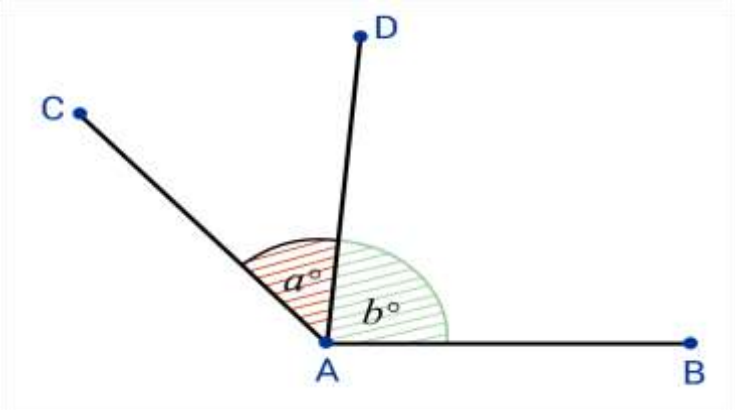


- A **reflex angle** is an angle that measures **more than 180 degrees but less than 360 degrees**.

Key Points:

- It is **larger than a straight angle**.
- It "goes around" the circle more than halfway.
- Range: **180° < Reflex angle < 360°**

Adjacent angles (share a vertex and side):



Adjacent angles are two angles that:

- Share a common vertex,
- Share a common arm, and
- Do not overlap.

Key Points:

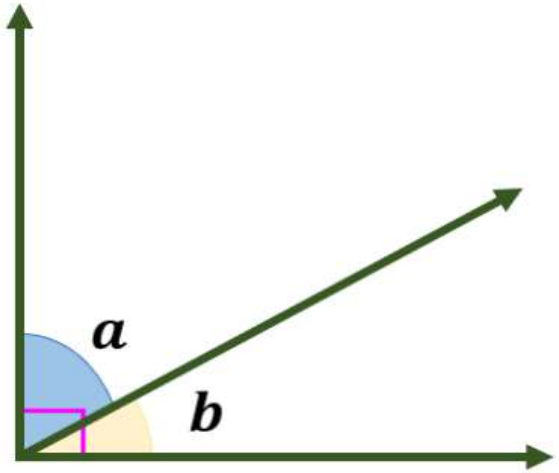
- They lie **next to each other**.
- The non-common arms form a **straight line or open shape**.
- They can form a **linear pair** if they are supplementary.

Complementary angles (sum = 90°)

- **Complementary angles** are **two angles whose sum is exactly 90 degrees**.

Key Points:

- Each angle is said to be the **complement** of the other.
- They **don't have to be adjacent**, but they can be.
- One or both angles must be **acute** (less than 90°).

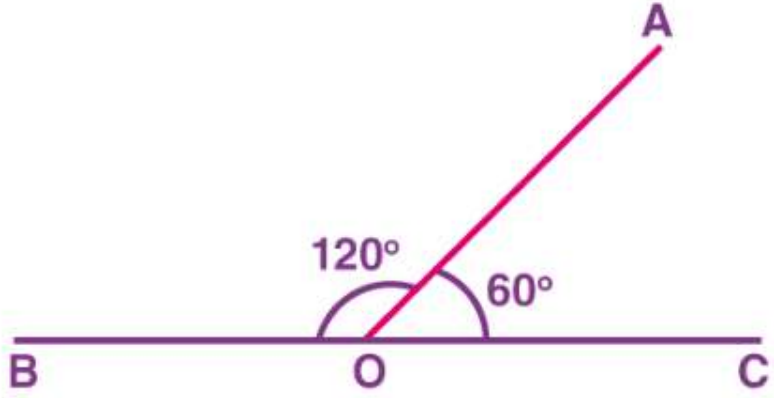


Supplementary angles (sum = 180°)

- **Supplementary angles** are **two angles whose sum is exactly 180 degrees**.

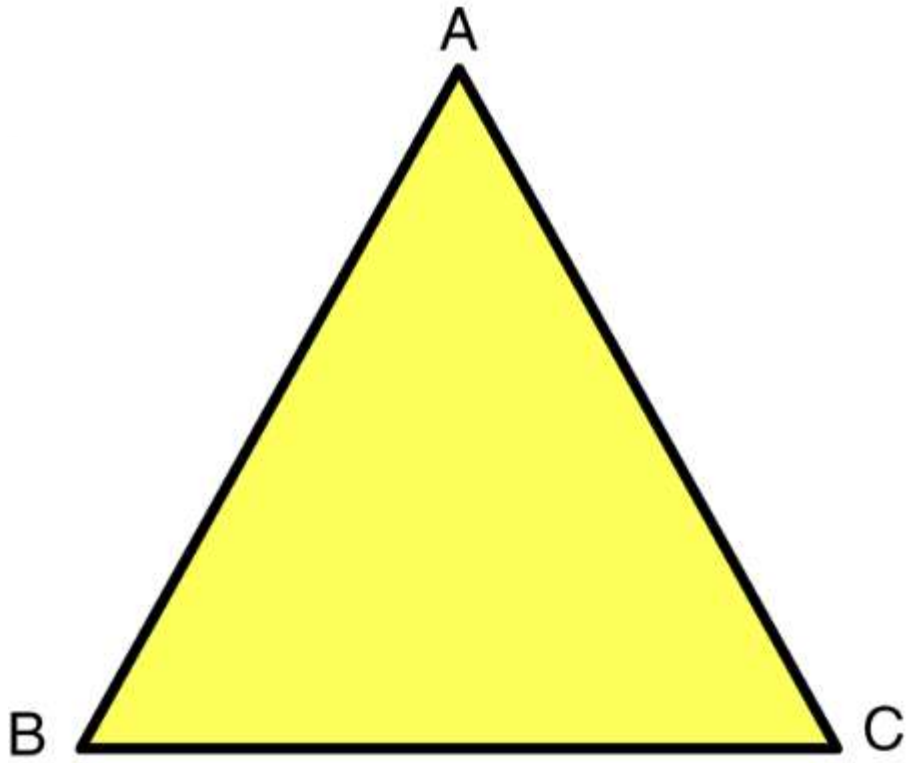
Key Points:

- Each angle is called the **supplement** of the other.
- They can be:
  - **Adjacent** (forming a straight line — called a linear pair), or
  - **Non-adjacent** (separate but still total 180°).



Triangles:

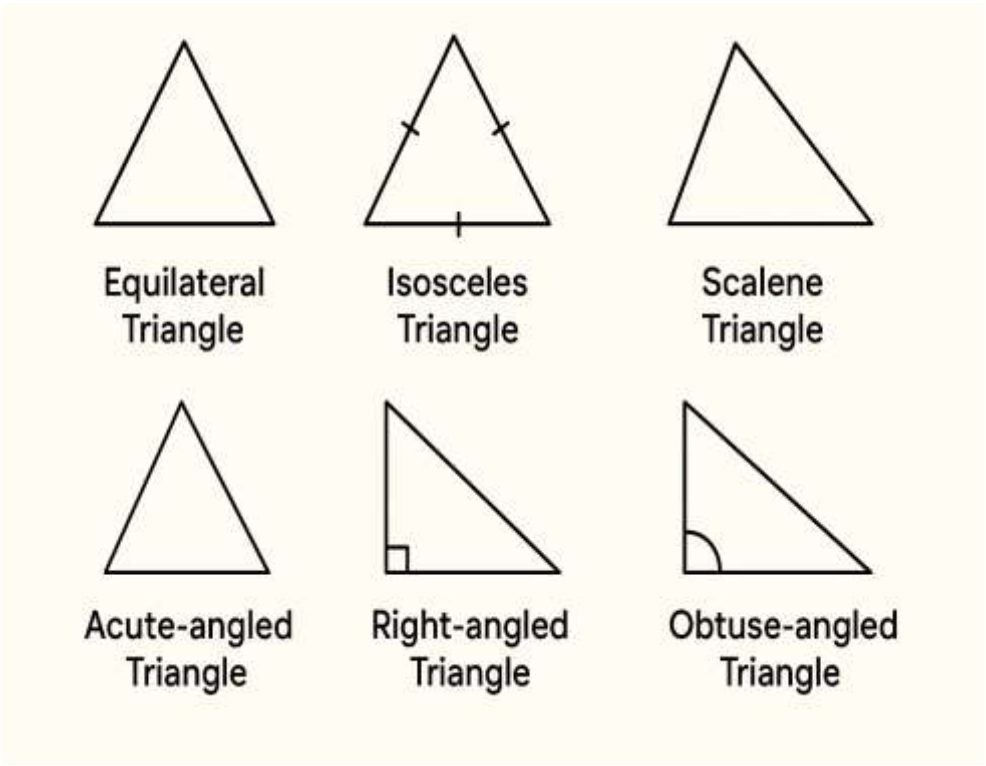
- A triangle is a polygon with three sides having three vertices.
- The angle formed inside the triangle is equal to 180 degrees.
- It means that the sum of the interior angles of a triangle is equal to 180°.



Types of Triangles:

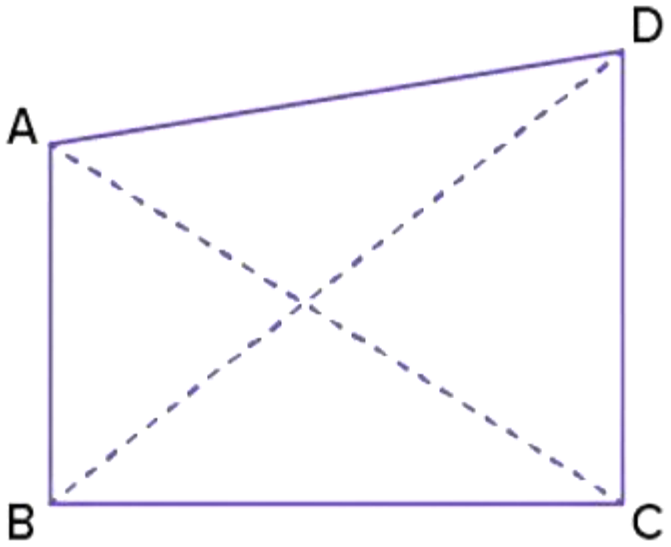
1. **Based on Sides:**
   - **Equilateral Triangle** – All three sides and angles are equal.
   - **Isosceles Triangle** – Two sides and two angles are equal.
   - **Scalene Triangle** – All sides and all angles are different.

2. **Based on Angles:**
   - **Acute-angled Triangle** – All angles are less than 90°.
   - **Right-angled Triangle** – One angle is exactly 90°.
   - **Obtuse-angled Triangle** – One angle is greater than 90°.



Quadrilaterals:

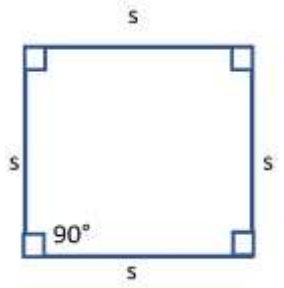
- A quadrilateral is a two-dimensional geometric shape with four sides (or edges), four vertices (or corners), and four angles.
- It is a polygon, and the term "quadrilateral" comes from the Latin words "quadri" (meaning four) and "lateral" (meaning side).
- The sum of the interior angles in any quadrilateral is always 360 degrees.



Types of Quadrilateral:

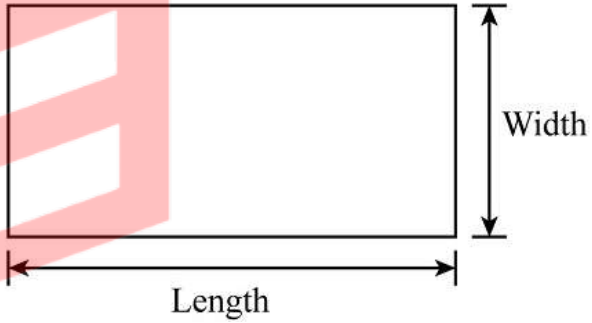
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Square:



- **All sides are equal** in length.
- **All angles are 90°.**
- **Opposite sides are parallel.**
- Diagonals bisect each other at **90°** and are equal.

Rectangle:



- **Opposite sides are equal and parallel**.
- **All angles are 90°.**
- Diagonals are equal but do **not** bisect at 90°.

Rhombus:

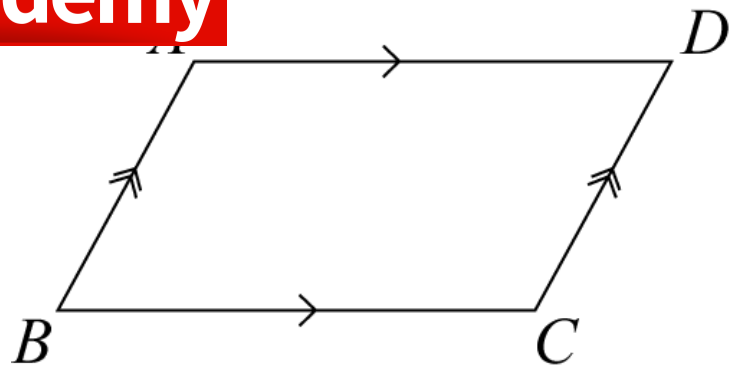


- All four sides are **equal**, like a square.
- Opposite angles are **equal**, but **not 90°**.
- Diagonals bisect at 90°, but are **not equal**.

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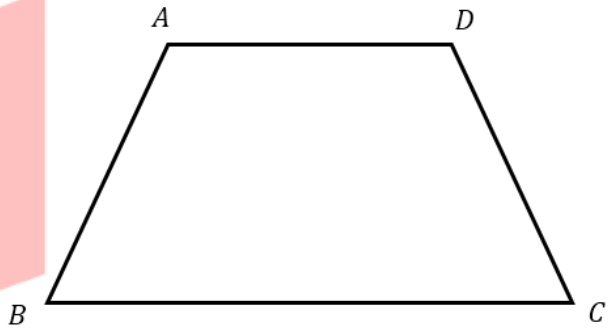
Rhomboid (Parallelogram):

- Opposite sides are **equal and parallel.**
- Opposite **angles are equal.**
- Diagonals don't bisect **at 90° and are not equal.**



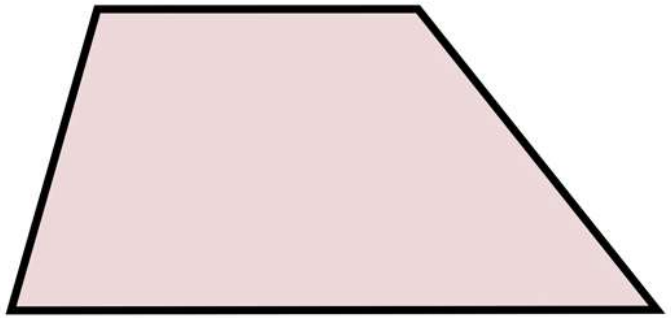
Trapezium:

- A quadrilateral with **one pair of opposite sides parallel**.
- Other sides are **non-parallel**.
- Angles are not equal.



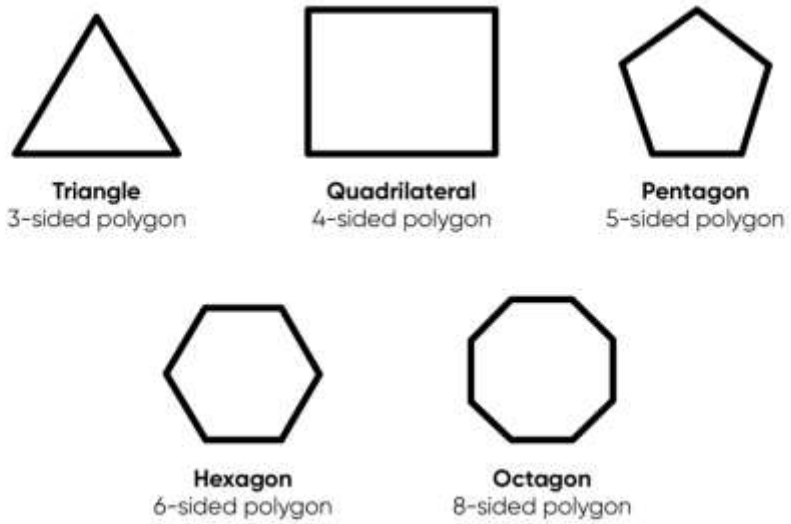
Trapezoid:

- A quadrilateral with **no sides parallel**.
- All sides and angles are different.



4. Polygon

- **Polygon** is a **closed 2D shape** made with **straight lines** only.
- It has **at least 3 sides** (no curves, no open ends).
- The lines meet at **corners called vertices**.
- **Examples** of polygons: Triangle, Square, Pentagon Hexagon, etc.
- **Not polygons**: Circles, ovals, or any shape with curves.

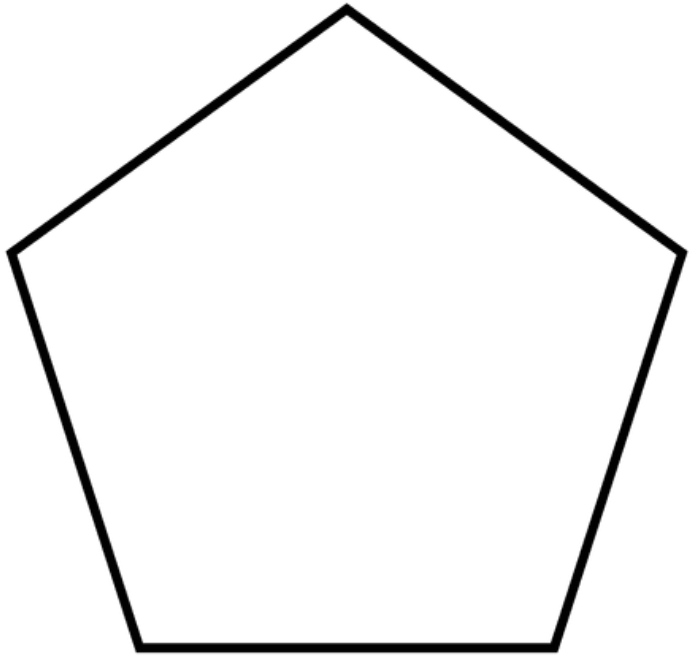


Formulae for Polygons:

- **Sum of Interior Angles**
  - Sum = (n-2) x 180°
    - Where n is number of sides
- **Each Interior Angle (Regular Polygon)**
  - Angle=((n−2)×180°)/n
    - Where n is number of sides
- **Each Exterior Angle (Regular Polygon)**
  - Exterior Angle=360°/n
    - Where n is number of sides

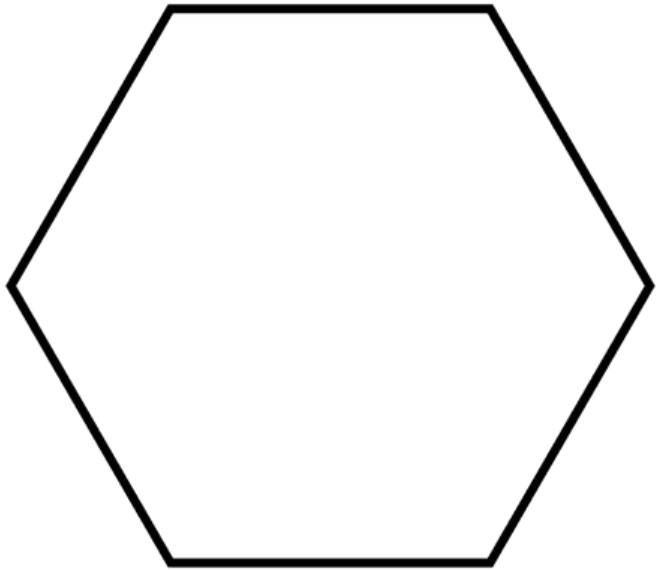
1. Pentagon

- **Number of Sides:** 5
- **Name Origin:** From the Greek word *pente* (meaning five) and *gon* (meaning angle).
- **Sum of Interior Angles:**
  $(5 - 2) \times 180° = 540°$
- **Each Interior Angle (Regular Pentagon):**
  $540° \div 5 = 108°$
- **Real-Life Example:** The Pentagon building in the USA (military headquarters), some home tiles.



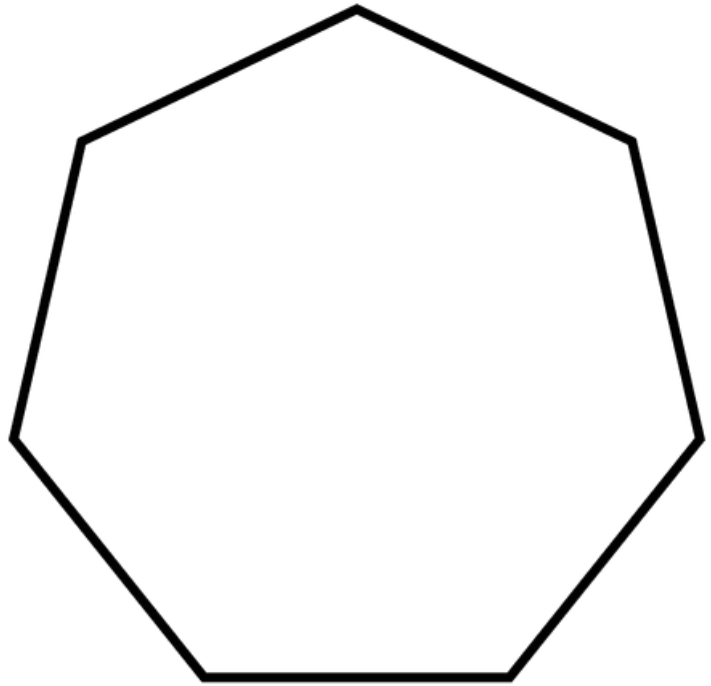
2. Hexagon

- **Number of Sides:** 6
- **Name Origin:** From Greek *hex* (meaning six) and *gon*.
- **Sum of Interior Angles:**
  $(6 - 2) \times 180° = 720°$
- **Each Interior Angle (Regular Hexagon):**
  $720° \div 6 = 120°$
- **Real-Life Example:** Honeycombs in beehives, nuts and bolts (hex heads).



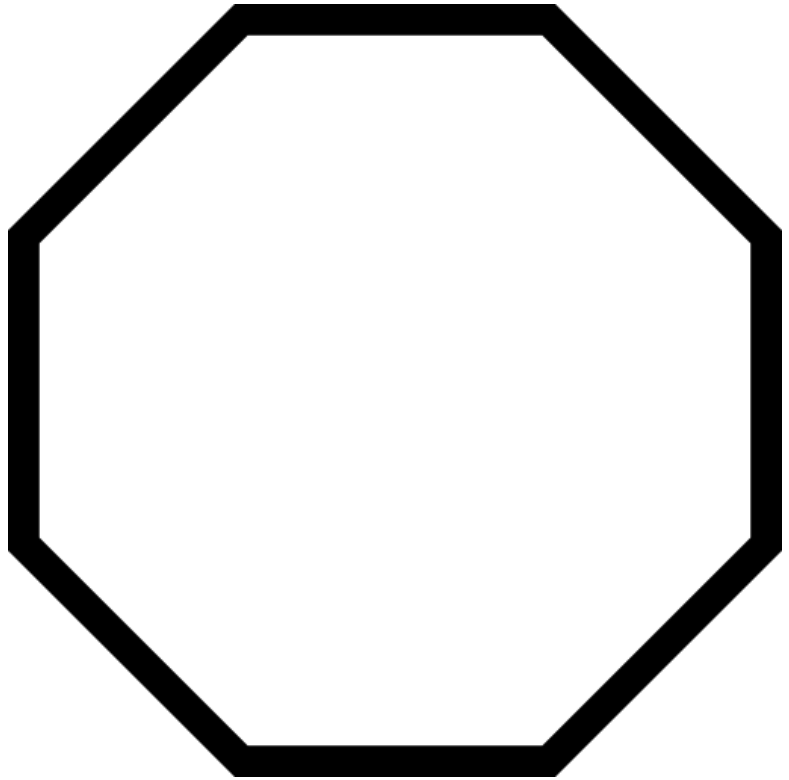
3. Heptagon

- **Number of Sides:** 7
- **Name Origin:** From Greek *hepta* (seven) and *gon*.
- **Sum of Interior Angles:**
  $(7 - 2) \times 180° = 900°$
- **Each Interior Angle (Regular Heptagon):**
  $900° \div 7 \approx 128.57°$
- **Real-Life Example:** Rare in real life, but used in some coin designs and artistic tilings.



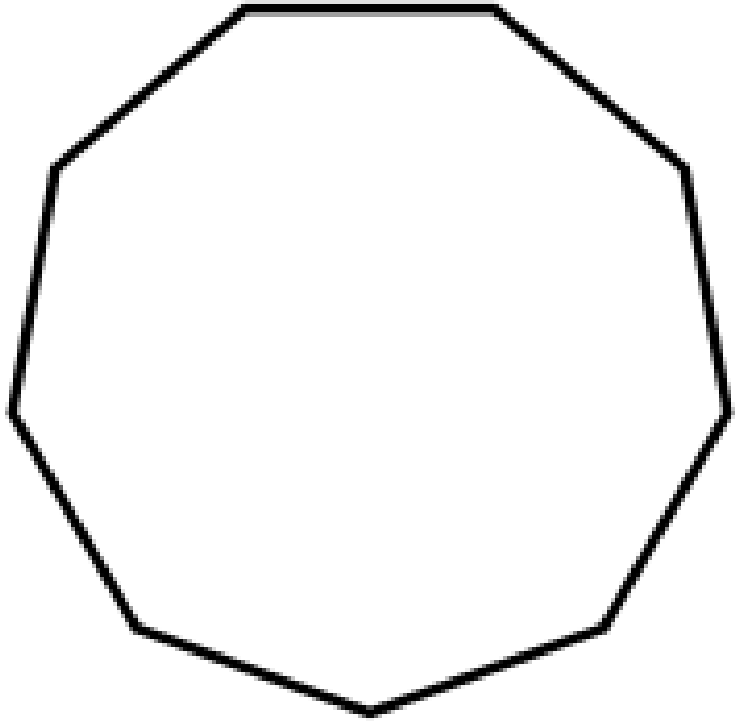
4. Octagon

- **Number of Sides:** 8
- **Name Origin:** From Greek *octa* (eight) and *gon*.
- **Sum of Interior Angles:**
  $(8 - 2) \times 180° = 1080°$
- **Each Interior Angle (Regular Octagon):**
  $1080° \div 8 = 135°$
- **Real-Life Example:** Stop signs (in many countries), bathroom mirrors.



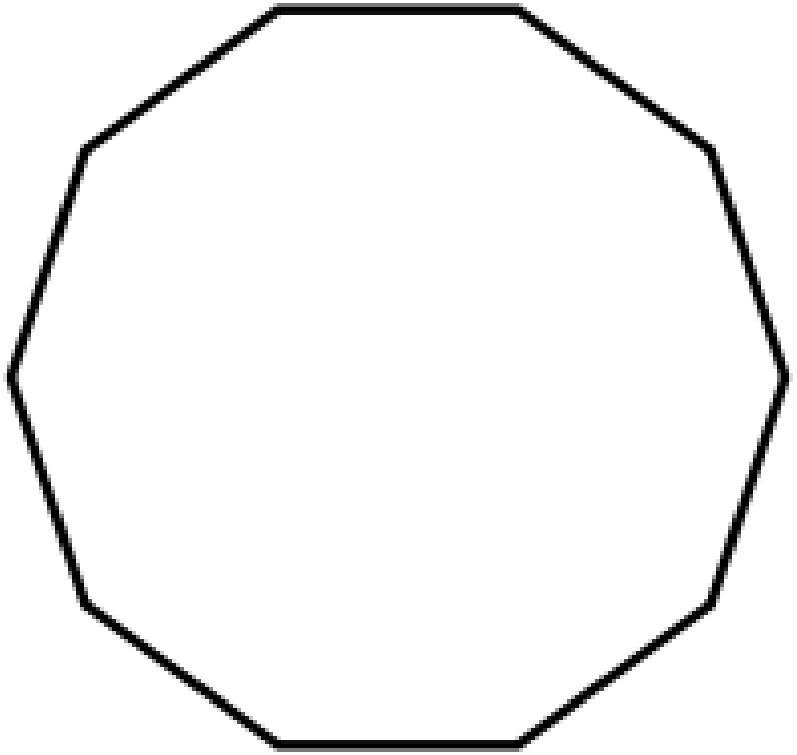
5. Nonagon

- **Number of Sides:** 9
- **Name Origin:** From Latin *nonus* (nine) and Greek *gon*.
- **Sum of Interior Angles:**
  $(9 - 2) \times 180° = 1260°$
- **Each Interior Angle (Regular Nonagon):**
  $1260° \div 9 \approx 140°$
- **Real-Life Example:** Often used in geometry puzzles and tiling art.



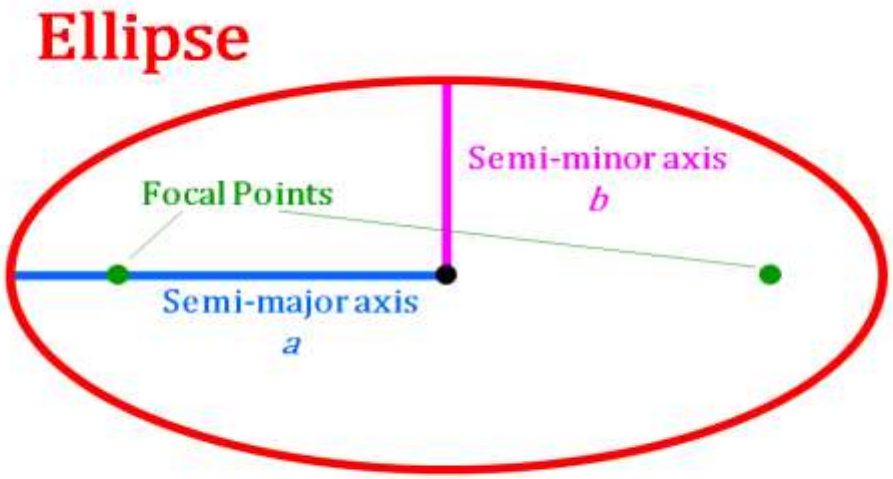
6. Decagon

- **Number of Sides:** 10
- **Name Origin:** From Greek *deca* (ten) and *gon*.
- **Sum of Interior Angles:**
  $(10-2) \times 180° = 1440°$
- **Each Interior Angle (Regular Decagon):**
  $1440° \div 10 = 144°$
- **Real-Life Example:** Coin designs, large decorative tilings.



1. Ellipse

- **Definition:**
  - An **ellipse** is a **closed curve** formed by all points such that the **sum of distances** from **two fixed points** (called **foci**) is **constant**.
  - It looks like a **flattened circle**.



- **Methods of Construction:**

1.Concentric Circle Method

1. Draw two concentric circles (same center, different radius).
2. Use radial lines and transfer distances to get points on ellipse.

2.Rectangle or Oblong Method

1. Draw a rectangle.
2. Divide sides into equal parts.
3. Join corresponding divisions to form ellipse.

3.String and Pin (Focus-Directrix) Method

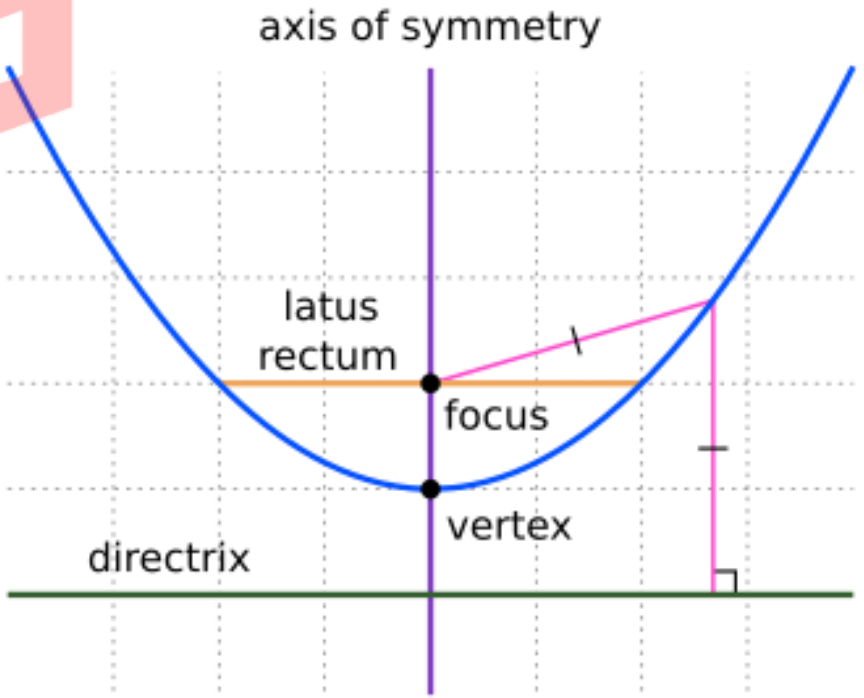
1. Fix two pins (foci), tie a string.
2. Use a pencil to keep the string tight and draw the curve.

2. Parabola

- **Definition:**

  - A **parabola** is a curve where **every point is equally distant** from a **fixed point** (focus) and a **fixed straight line** (directrix).

  - It looks like a **U-shape**.



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- **Methods of Construction:**

1.Rectangle Method

1. Draw a rectangle.
2. Divide sides equally.
3. Join lines diagonally to find the curve.

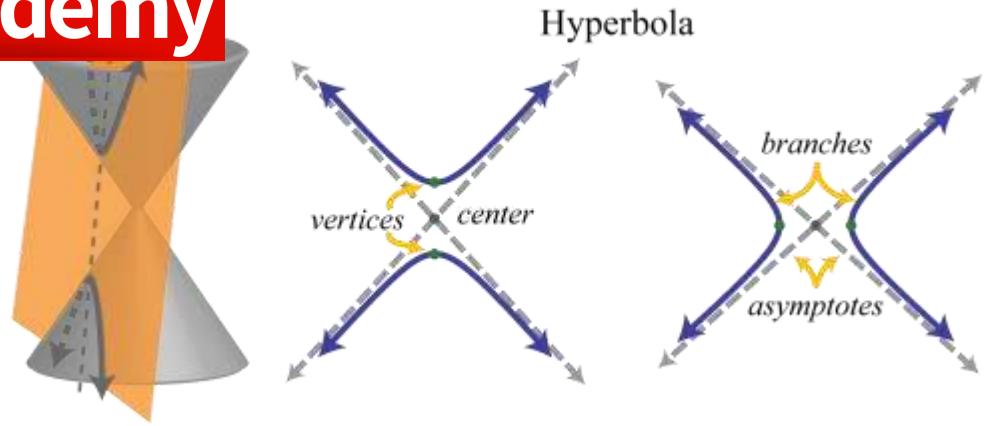
2.Focus-Directrix Method

1. Draw a directrix line and mark the focus.
2. Use perpendicular bisectors between points on directrix and focus.

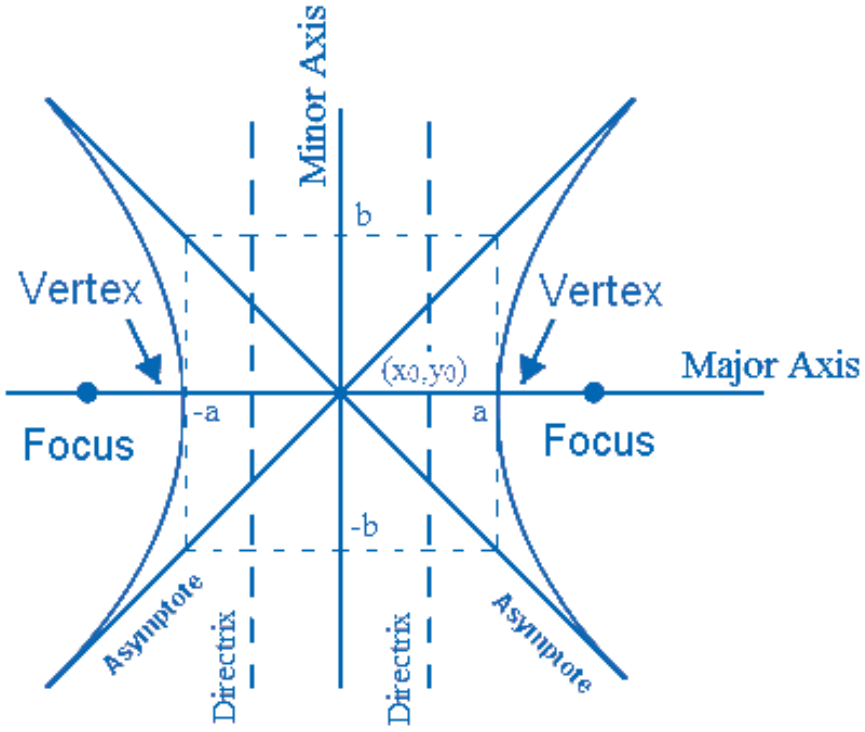
3.Offset Method

1. Mark vertex, axis, and take equal intervals to generate curve using offsets.

3. Hyperbola



- **Definition:**
  - A **hyperbola** is a curve formed by all points such that the **difference of distances** from **two fixed points** (foci) is **constant**.
  - It has **two separate curves** called **branches**.



- **Methods of Construction:**

1.Focus-Directrix Method

1. Similar to parabola, but ratio of distances > 1.
2. Points are located where PF/PD = e (eccentricity > 1).

2.Asymptote Method

1. Draw asymptotes (guiding lines).
2. Use points near intersection to sketch curve approaching them.

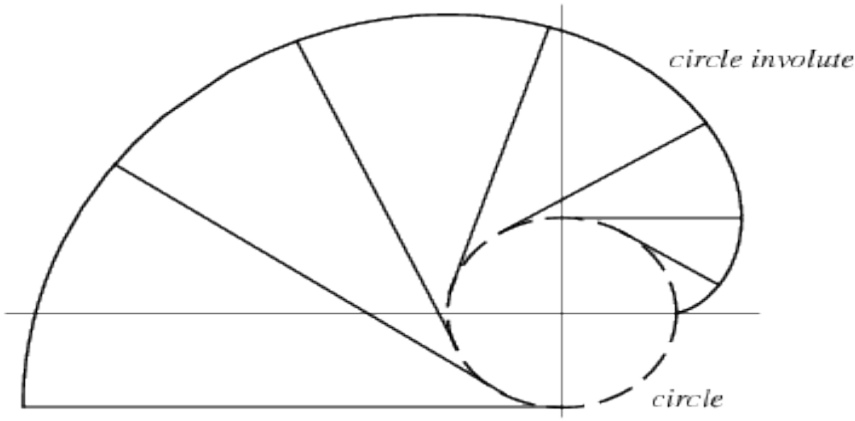
3.Rectangular Hyperbola Method

1. Used when asymptotes are at right angles.
2. Use coordinate points for plotting branches.

1. Involute

- **Definition:**
  - An **involute** is a curve traced by the **end of a string** as it is **unwound** from a shape (like a circle or polygon) while keeping the string **tight**.

- **Method of Drawing (Involute of a Circle):**

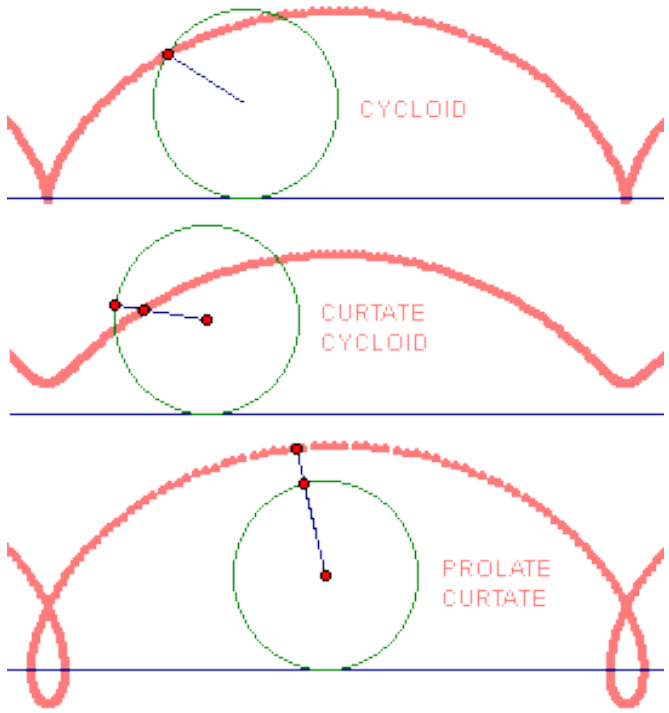


1. Draw a circle (called base circle).
2. Divide the circle into **equal parts** (e.g., 8 or 12).
3. Draw **tangents** at each division point.
4. Measure and mark the **length of arc** from the starting point on each tangent.
5. Connect all the marked points smoothly – this is the involute.

2.Cycloidal Curves

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- **Definition:**
  - A **cycloid** is the path traced by a point on the circumference of a **rolling circle** (without slipping) along a straight line.



- **Types:**
  - **Cycloid** – point on the **rim** of the rolling circle.
  - **Epicycloid** – point on a circle rolling **outside another circle**.
  - **Hypocycloid** – point on a circle rolling **inside another circle**.

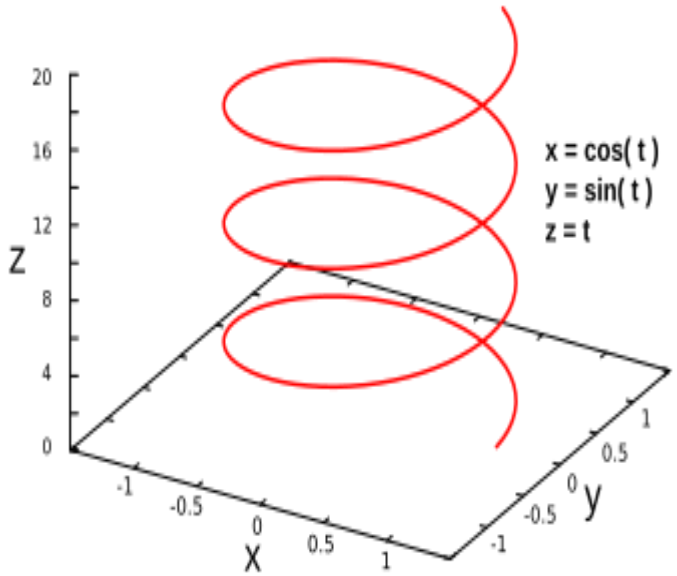
- **Method of Drawing (Cycloid):**

1.Draw a **baseline** and a **circle** that will roll on it.
2.Divide the circle and the baseline into **equal parts**.
3.For each division, rotate the circle and track the position of the point on its rim.
4.Mark all positions and connect them smoothly.

3. Helix

- **Definition:**
  - A **helix** is a **3D curve** generated by a point moving around a **cylinder or cone**, while also moving **upwards or downwards** at a constant rate.
  - Like a **screw thread or spring**.

- **Types:**
  - **Cylindrical Helix** – on a cylinder (most common).
  - **Conical Helix** – on a cone.



- **Method of Drawing (Cylindrical Helix):**

1. Draw the **top view** (a circle) and **side view** (a rectangle).
2. Divide both views into **equal parts**.
3. Project points from top view to front view.
4. Mark heights on front view based on pitch and divisions.
5. Join the points with a smooth curve – the helix.

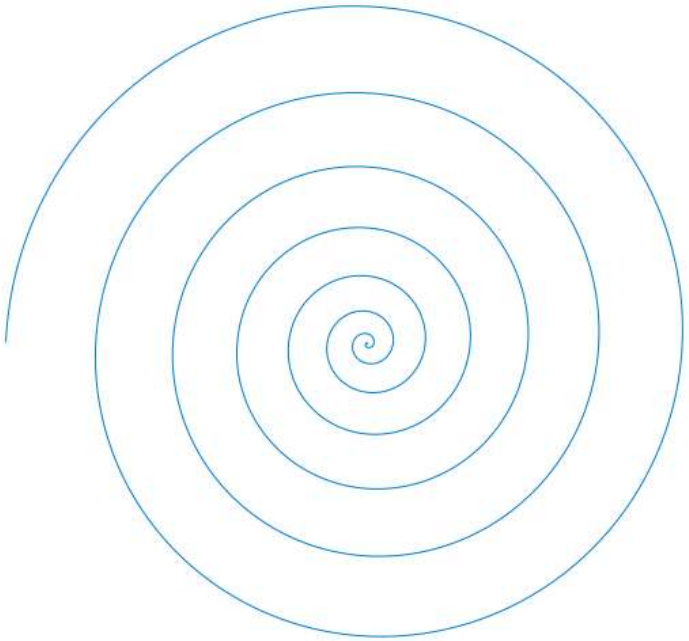
4. Spiral

- **Definition:**
  - A **spiral** is a **2D curve** that **starts at a point (pole)** and **moves outward** while rotating around the center.

- **Types:**
  - **Archimedean Spiral** – radius increases uniformly with angle.
  - **Logarithmic Spiral** – radius increases exponentially.

- **Method of Drawing (Archimedean Spiral):**

  1. Draw **concentric circles** with increasing radii.
  2. Divide the full circle (360°) into **equal angles** (e.g., 30°, 45°).
  3. At each angle, mark the point at the respective radius.
  4. Connect all points with a smooth curve.



Scale:

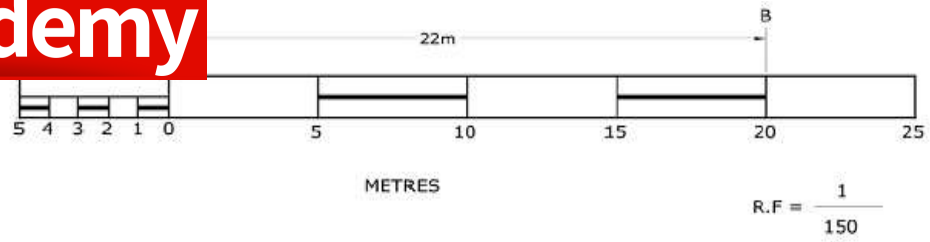
- In engineering drawings, a scale is the ratio between the size of an object as represented on a drawing and its actual size.
- It essentially defines how much the object is reduced or enlarged in the drawing compared to its real-world dimensions.
- Scales are crucial for accurately representing objects of various sizes, from tiny electronic components to massive buildings, on a manageable drawing sheet.



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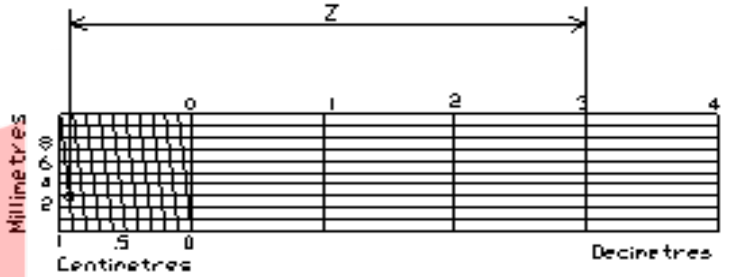
Plain Scale – simple ratio-based scale

- A plain scale is the most basic type of scale used to represent distances in a drawing.



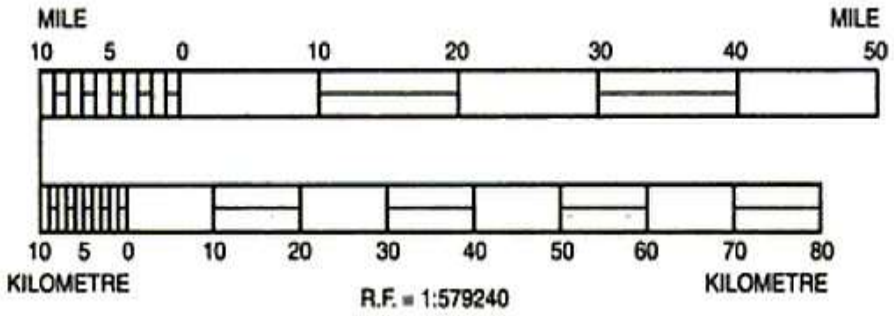
Diagonal Scale – for high precision

- A diagonal scale is a more advanced scale used to measure very small units of length, typically three consecutive units.



Comparative Scale – to compare two units

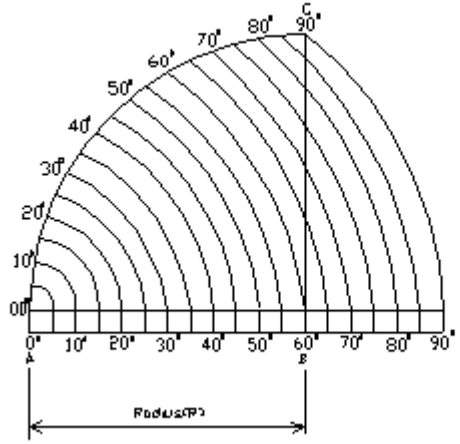
- A comparative scale consists of two different plain or diagonal scales constructed with the *same* Representative Fraction (R.F.) but graduated to read in *different* units of measurement.





Vernier Scale – precise measuring (used in vernier calipers)

- A vernier scale is a highly precise scale used for taking very accurate measurements, often to two or more decimal places of a unit.



Scale of Chords – used in constructing angles without protractor

- Unlike the other scales which are used for linear measurements, the Scale of Chords is specifically designed for constructing angles on a drawing without the use of a protractor.

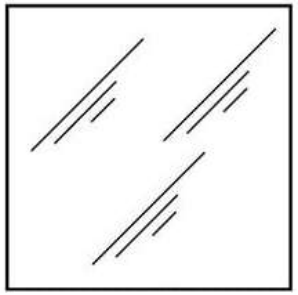
Standard Symbols for Materials in Engineering Drawing

1. Metals – cross hatching



- The most common symbol for general metals (like steel, cast iron, copper, aluminum, etc.) in section is **parallel diagonal lines** (often at 45∘ to the object's outline). These lines are typically thin and evenly spaced.

2. Glass – double lines or broken lines



- Glass is commonly represented by **thin, double parallel lines** that run diagonally across the sectioned area.

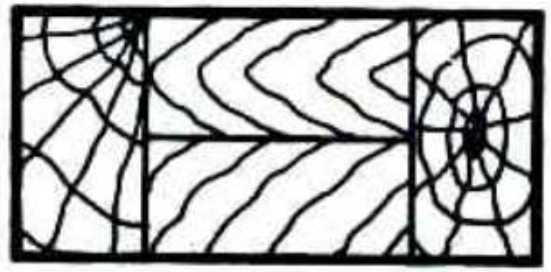
3. Liquids – wavy patterns



- Liquids (like water, oil, fuel) in a section view are typically represented by **wavy or irregular horizontal lines**.

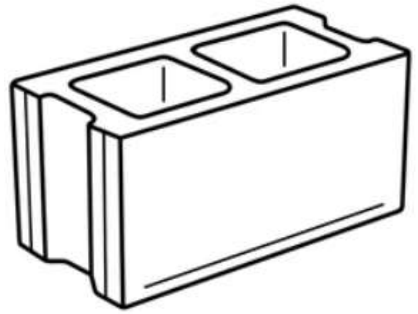
4. Wood – grain pattern

- Wood is symbolized by a **distinctive grain pattern** in section. This usually involves drawing irregular, often slightly curved, parallel lines that mimic the natural rings and texture of wood.



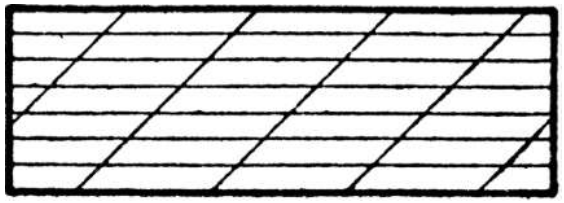
5. Concrete – dots and hatching

- Concrete is represented by a combination of **randomly placed small dots and light, often widely spaced, cross-hatching**.



6. Packing and insulation – dashed or zigzag lines

- This category includes a variety of materials like felt, rubber, cork, fiberglass, and other soft or fibrous substances used for sealing, damping, or thermal/acoustic insulation.



Sparks Academy

1) Which of the following defines a reflex angle?

A) Less than 90° B) Equal to 180° C) Between 90° and 180° D) Greater than 180° but less than 360°

✓ **Correct Answer:** D

2) Which statement is true about rhombus and rhomboid?

A) Both have equal diagonals

B) Rhombus has all sides equal and diagonals at 90°, rhomboid doesn't

C) Rhomboid has all angles 90°

D) Rhombus and rhomboid are the same

✓ **Correct Answer:** B

1) பிரதிபலன்கோணம் எவ்வாறு வரையறுக்கப்படுகிறது?

A) 90°-க்கும் குறைவாக B) 180°

C) 90°–180° D) 180°–360°

✓ **சரியான பதில்:** D

2) ராம்பஸ் மற்றும் ராம்பாயிட் குறித்த உண்மை கூற்று எது?

A) இரண்டும் சம கோடுகள் உள்ளன

B) ராம்பஸில் எல்லா பக்கமும் சமம், கோடுகள் 90°, ராம்பாயிட் அல்ல

C) ராம்பாயிடில் எல்லா கோணங்களும் 90°

D) இரண்டும் ஒரே மாதிரியானவை

✓ **சரியான பதில்:** B

3) An involute is:
A) Curve formed by focus and directrix
B) Curve traced by unwinding string from a shape
C) 3D spiral around a cone
D) Irregular polygon
✓ **Correct Answer:** B

4) Comparative scale is used to:
A) Draw angles only
B) Measure very small lengths
C) Compare two different units
D) Construct regular polygons
✓ **Correct Answer:** C

3) இன்பால்யூட் என்பது:
A) கவனம் மற்றும் திசை கோட்டில் உருவாகும் வளைவு
B) வட்டத்திலிருந்து நூலை அவிழ்த்து வரையும் வளைவு
C) கோணத்தில் சுழலும் ஸ்பைரல்
D) இடர்பாடுள்ள பன்முகம்
✓ **சரியான பதில்:** B

4) ஒப்பீட்டு அளவீடு பயன்படுத்தப்படும் இடம்:
A) கோணங்களை வரைய B) சிறிய நீளங்களை அளக்க
C) இரண்டு அலகுகளை ஒப்பிட D) பன்முகங்களை வரைய
✓ **சரியான பதில்:** C

5) A helix is best described as:
A) 2D curved line inside a triangle
B) A spiral on a flat surface
C) A 3D curve wound around a cylinder or cone
D) Polygonal figure
✓ **Correct Answer:** C

5) ஹெலிக்ஸ் என்பது:
A) முக்கோணத்துக்குள் உள்ள வளைவு
B) சமமான சுற்றவளைவு
C) சிலிண்டர் அல்லது கோணத்தின் மீது சுழலும் 3D வளைவு
D) பன்முக வடிவம்
✓ **சரியான பதில்:** C

6) What is the sum of interior angles of a nonagon?
A) 1080° B) 1260° C) 1440° D) 900°
✓ **Correct Answer:** B

6) நவகோணத்தின் உள் கோணங்களின் மொத்தம் என்ன?
A) 1080° B) 1260° C) 1440° D) 900°
✓ **பதில்:** B

Sparks Academy

7) What is the exterior angle of a regular decagon?

A) 36° B) 45° C) 30° D) 60°

✓ **Correct Answer:** A

7) ஒரு டெககானில் வெளி கோணத்தின் அளவு:

A) 36° B) 45° C) 30° D) 60°

✓ **பதில்:** A

8) Each interior angle of a regular pentagon is:

A) 108° B) 120° C) 135° D) 140°

✓ **Correct Answer:** A

8) ஒரு ஐம்பக்கத்தின் ஒவ்வொரு உள் கோணமும்:

A) 108° B) 120° C) 135° D) 140°

✓ **பதில்:** A

9) To construct an involute of a circle, you must:

A) Use radial bisectors

B) Divide the base circle and draw tangents

C) Use a focus and directrix

D) Measure diagonals

✓ **Correct Answer:** B

9) ஒரு வட்டத்தின் இன்பால்யூட் வரைய வேண்டுமெனில்:

A) மைய புள்ளி பயன்படுத்த வேண்டும்

B) வட்டத்தைப் பிரித்து டாங்கெண்ட் வரைய வேண்டும்

C) கவன புள்ளி மற்றும் திசை கோடு

D) கோண அளவை மட்டும்

✓ **பதில்:** B

10) Cycloid is a curve traced by a point on a circle:

A) Rolling without slipping on a line

B) Spinning in air

C) Inside another circle

D) With slipping

✓ **Correct Answer:** A

10) ஒரு சைக்க்லாய்டு எப்போது உருவாகிறது?

A) உருண்டு செல்லும் புள்ளி B) சுழலும் புள்ளி

C) சுற்றுவட்டத்தின் உள்ளே D) தடிமனான உருளுதல்

✓ **பதில்:** A

Sparks Academy

11) Pitch of a cylindrical helix is the distance between:

A) Two turns in top view

B) Two adjacent divisions

C) Two successive turns in side view

D) Vertical height

✓ **Correct Answer:** C

11) உருளை வடிவ ஹெலிக்ஸில் Pitch என்பது:

A) மேல் தோற்றம் ஓர் இடைவெளி

B) இரண்டு பாகங்களை இணைக்கும் தூரம்

C) எதிர்வினை நிலை உயரம்

D) உச்சம் வரை உயரம்

✓ **பதில்:** C

12) What is the RF to draw a 5 km diagonal scale to 100 m precision?

A) 1:100 B) 1:100000 C) 1:500 D) 1:10000

✓ **Correct Answer:** B

12) RF = ? என்றால் 5 கி.மீ அளவுக்கு 100 மீ துல்லியம் பெறலாம்:

A) 1:100 B) 1:100000 C) 1:500 D) 1:10000

✓ **பதில்:** B

13) What is the interior angle of a regular octagon?

A) 135° B) 120° C) 108° D) 140°

✓ **Correct Answer:** A

13) ஒரு எட்டுபக்கத்தின் ஒவ்வொரு உள் கோணமும்:

A) 135° B) 120° C) 108° D) 140°

✓ **பதில்:** A

14) Interior angle of a regular hexagon is:

A) 120° B) 140° C) 135° D) 144°

✓ **Correct Answer:** A

14) ஒரு அறுபக்கத்தின் உள் கோணத்தின் அளவு:

A) 120° B) 140° C) 135° D) 144°

✓ **பதில்:** A

15) Sum of angles in a triangle is:
A) 180° B) 360° C) 90° D) 270°
✓ **Correct Answer:** A

15) முக்கோணத்தில் கோணங்களின் மொத்தம்:
A) 180° B) 360° C) 90° D) 270°
✓ **பதில்:** A

16) Which curve has two branches and constant difference from foci?
A) Ellipse B) Parabola C) Hyperbola D) Spiral
✓ **Correct Answer:** C

16) இரண்டு கவன புள்ளிகளுக்கிடையே மாறாத வித்தியாசம் கொண்ட வளைவு:
A) எலிப்ஸ் B) பரபொலா C) ஹைப்பர்பொலா D) ஸ்பைரல்
✓ **பதில்:** C

17) What is the total of exterior angles of any polygon?

A) 360° B) 180° C) Depends on sides D) 540°

✓ **Correct Answer:** A

18) A scale that allows measuring angles without a protractor is:

A) Vernier scale B) Scale of chords

C) Diagonal scale D) Plain scale

✓ **Correct Answer:** B

17) ஏதொரு பன்முகத்திலும் வெளி கோணங்களின் மொத்தம்:

A) 360° B) 180° C) பக்கங்களின் எண்ணிக்கையில் மாறும் D) 540°

✓ **பதில்:** A

18) ப்ரோத்ராக்டர் இல்லாமல் கோணங்களை அளவிடும் அளவீடு:

A) வெர்னியர் அளவீடு B) கோணச்சக்கரம்

C) கோண அளவீடு D) சாதாரண அளவீடு

✓ **பதில்:** B

19) In a trapezium, how many sides are parallel?

A) Two B) One pair only

C) All sides D) None

✓ **Correct Answer:** B

19) ஒரு சாயங்கோணத்தில் எத்தனை பக்கங்கள் இணையானவை?

A) இரண்டு B) ஒரு ஜோடி மட்டும்

C) எல்லா பக்கமும் D) ஒன்றுமில்லை

✓ **பதில்:** B

20) A regular polygon with 6 sides is called:

A) Pentagon B) Hexagon C) Octagon

D) Heptagon

✓ **Correct Answer:** B

20) அறுபக்க பன்முகம் எது?

A) ஐம்பக்கம் B) அறுபக்கம் C) எட்டுபக்கம்

D) ஏழுபக்கம்

✓ **பதில்:** B