Analytical Geometry

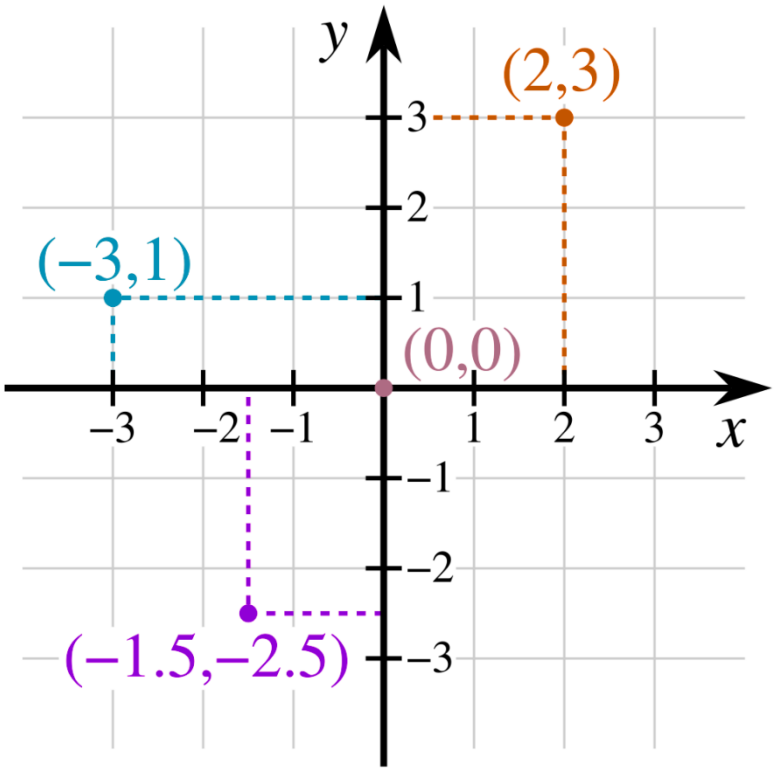
Points

Definition of a Point

- A point is the most basic element in geometry. It represents a specific location in space and has no size, length, width, or depth.
- In analytical geometry, a point is defined using coordinates:
  - In **2D** space: $P(x, y)$
  - In **3D** space: $P(x, y, z)$
- For remedial mathematics, we usually focus on the 2D Cartesian plane.

Cartesian Coordinate System

- The 2D Cartesian plane consists of two perpendicular number lines:
  - **x-axis**: Horizontal axis
  - **y-axis**: Vertical axis
- Their intersection is the **origin**, denoted as $O(0,0)$.



Four points are marked and labeled with their coordinates: (2, 3) in Orange, (−3, 1) in Blue, (−1.5, −2.5) in Purple, and the origin (0, 0).

Coordinates of a Point

- **x-coordinate (abscissa):** Horizontal distance from the y-axis
- **y-coordinate (ordinate):** Vertical distance from the x-axis

Example:

- The point $P(3,4)$is 3 units right of the y-axis and 4 units above the x-axis.

Quadrants of the Cartesian Plane

- The coordinate plane is divided into **four quadrants**:

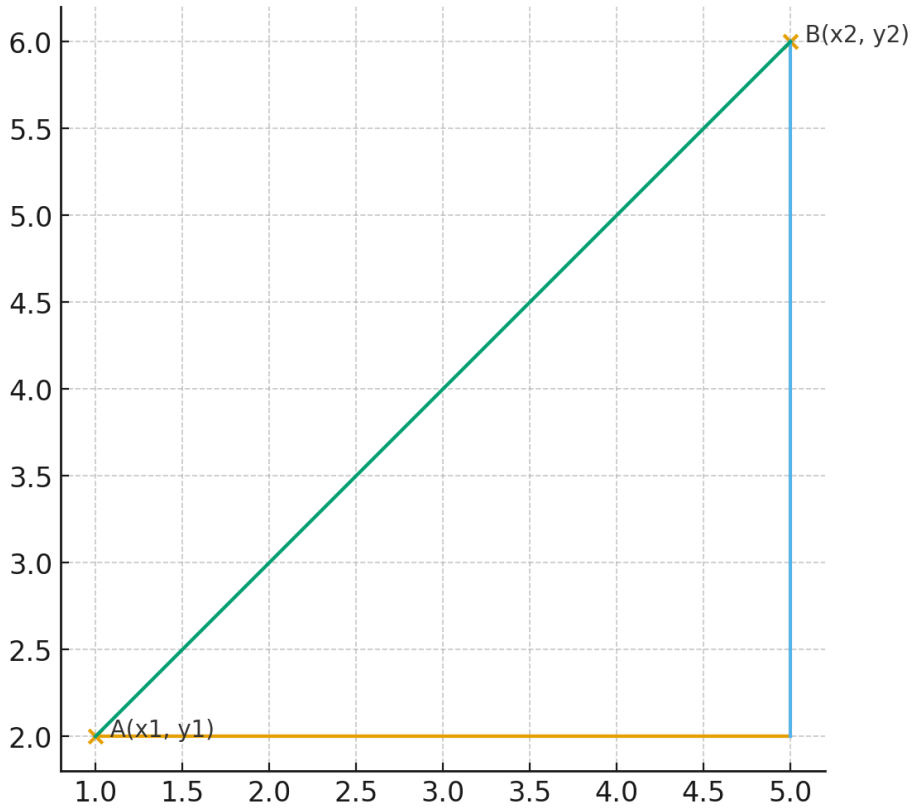
Quadrant	x-coordinate	y-coordinate
I	+	+
II	–	+
III	–	–
IV	+	–

Identifying Quadrants

- The sign of a point's coordinates determines which quadrant it lies in.

Distance Between Two Points

- Given two points:
  - $A(x_1, y_1)$
  - $B(x_2, y_2)$



Distance Formula

$$AB = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Derivation (Using Pythagoras Theorem)

- If you draw a right triangle with:
  - Horizontal side = | $x_2 - x_1$ |
  - Vertical side = | $y_2 - y_1$ |
- Then the distance between the points is the hypotenuse of that triangle.

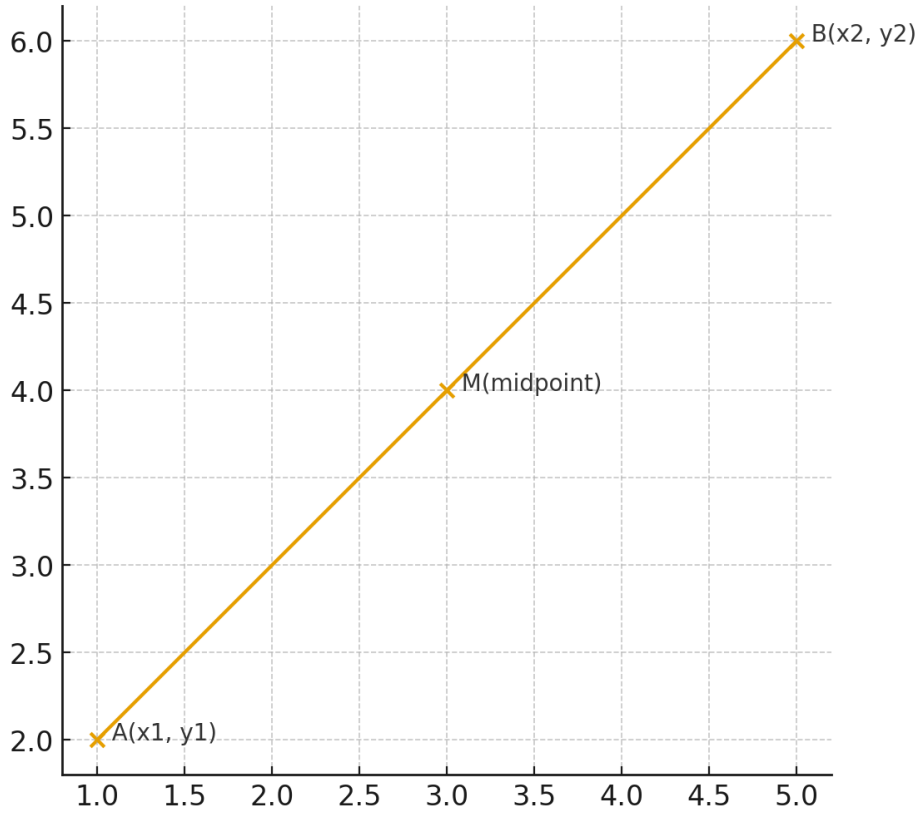
Midpoint of a Line Segment

- If $A(x_1, y_1)$and $B(x_2, y_2)$are endpoints of a line segment:

Midpoint Formula

$$M = (\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2})$$

- This gives the point exactly halfway between $A$and B.



Section Formula

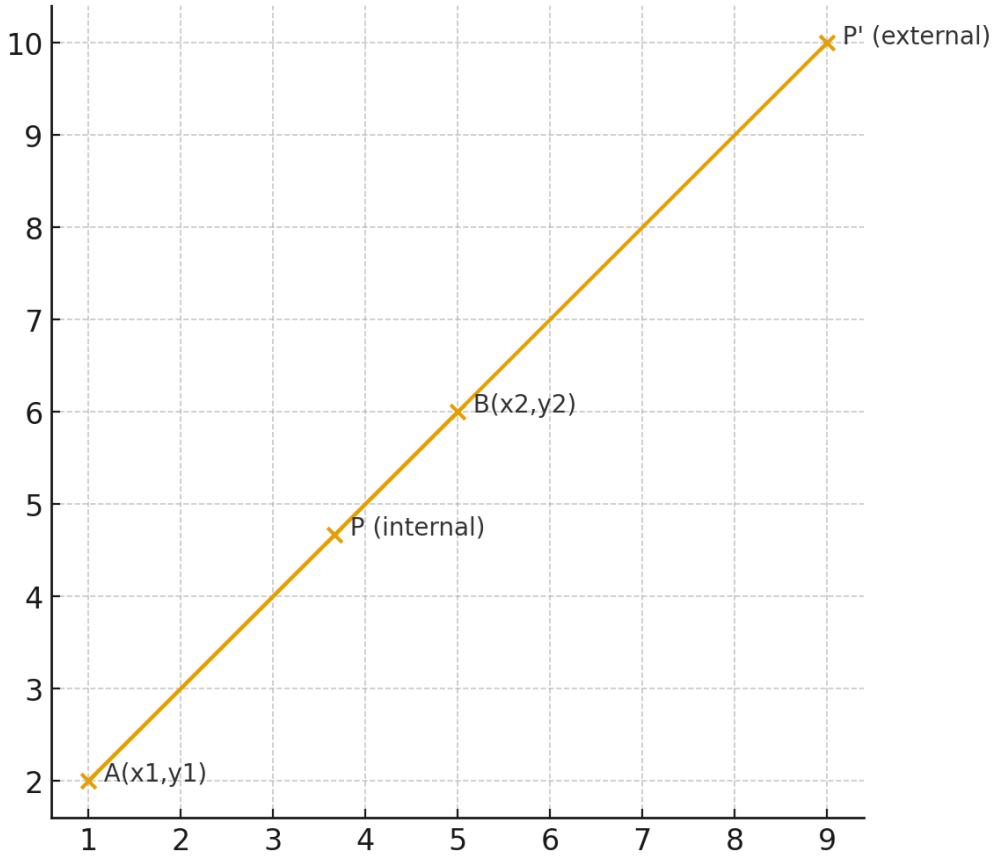
- If a point Pdivides the line segment joining $A(x_1, y_1)$and $B(x_2, y_2)$in the ratio $m: n$:

Internal Division

$$P = (\frac{mx_2 + nx_1}{m + n}, \frac{my_2 + ny_1}{m + n})$$

External Division

$$P = (\frac{mx_2 - nx_1}{m - n}, \frac{my_2 - ny_1}{m - n})$$



- These formulas are used to find the coordinates of a point that divides a line segment in a given ratio, either internally or externally.

Centroid of a Triangle

- Given the vertices of a triangle:
  - $A(x_1, y_1)$
  - $B(x_2, y_2)$
  - $C(x_3, y_3)$

Centroid Formula

$$G = (\frac{x_1 + x_2 + x_3}{3}, \frac{y_1 + y_2 + y_3}{3})$$

➢ The centroid $G$is the point of intersection of the medians and is considered the triangle's center of mass.

Straight Line

Slope or Gradient of a Straight Line

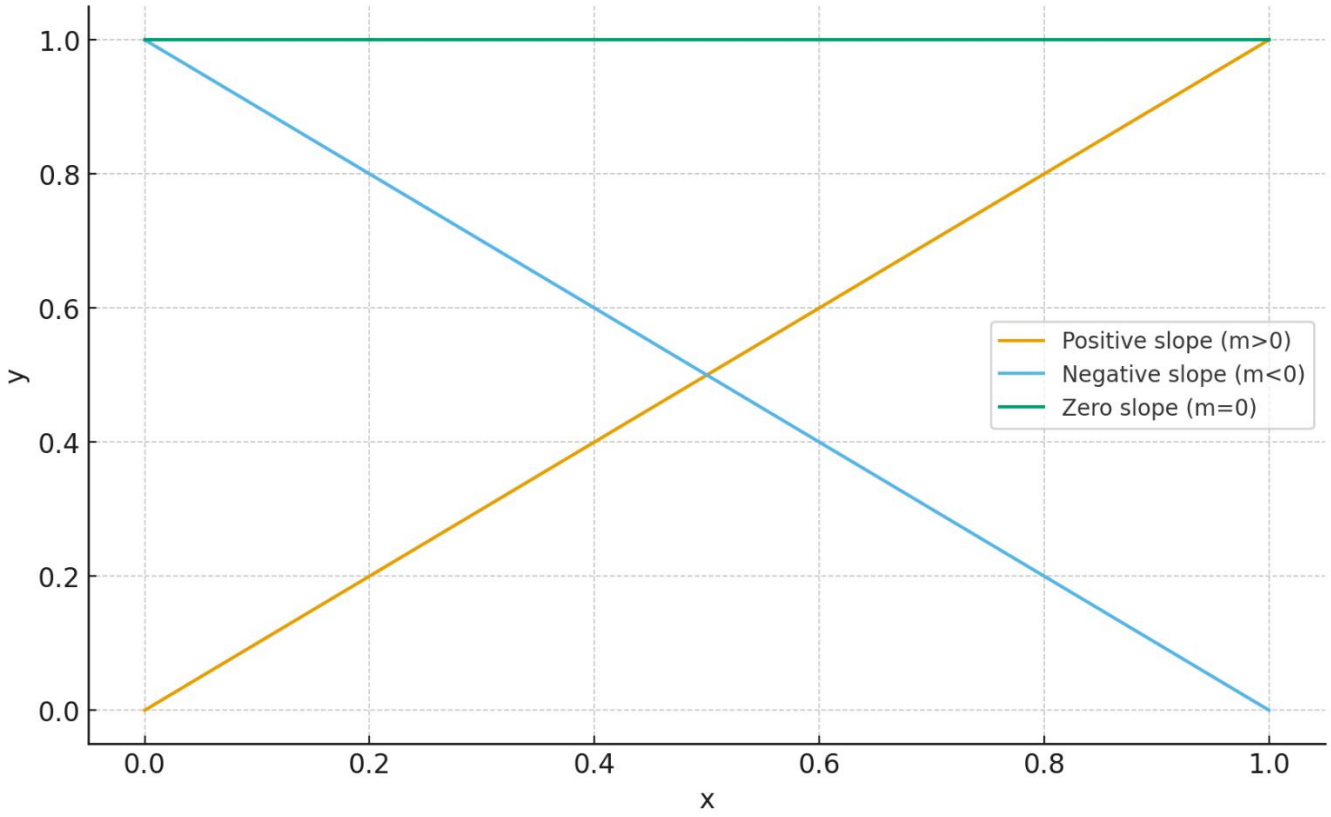
Definition of Slope (Gradient)

- The **slope** (also called **gradient**) of a straight line measures how steep the line is.
- It is a ratio that describes how much the **y-value** (vertical) of a point on the line changes for a given change in the **x-value** (horizontal).
- It is denoted by the letter **m**.
- For a non-vertical line, the **slope** is defined as:

$$m = \frac{\text{Change in y}}{\text{Change in x}} = \frac{y_2 - y_1}{x_2 - x_1}$$

- Where:
  - (x_1, y_1) and (x_2, y_2) are two distinct points on the line.

Interpretation of Slope:



- If **m > 0**, the line rises from left to right (positive slope).
- If **m < 0**, the line falls from left to right (negative slope).
- If **m = 0**, the line is **horizontal** (zero slope).
- If **m is undefined** (denominator is 0), the line is **vertical** (infinite slope).

Example:

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