

# Analytical Geometry

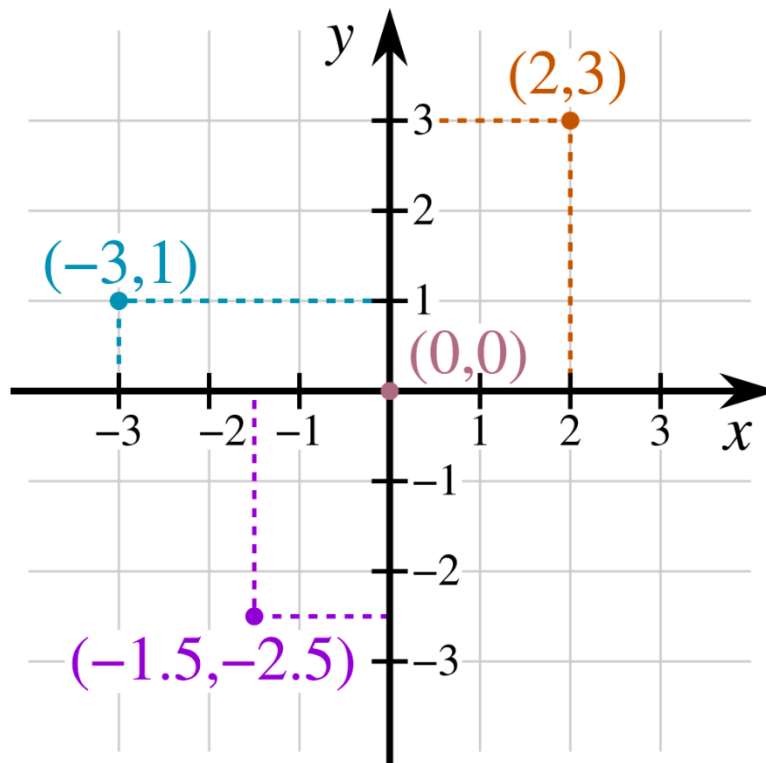
## Points

### 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**

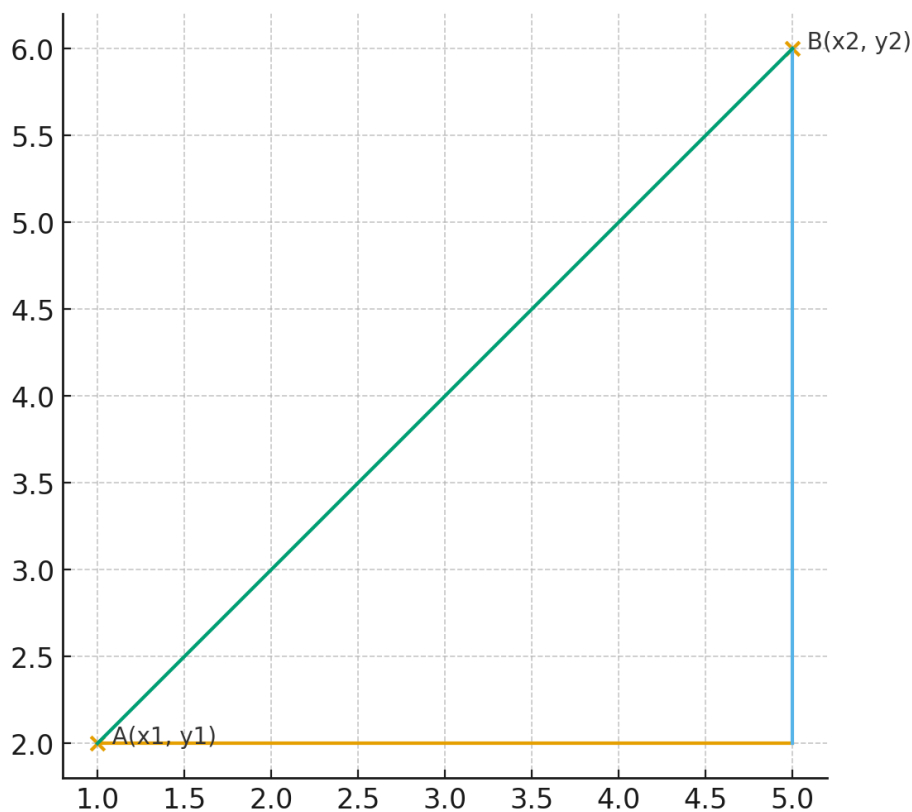
- The sign of a point's coordinates determines which quadrant it lies in.

**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.

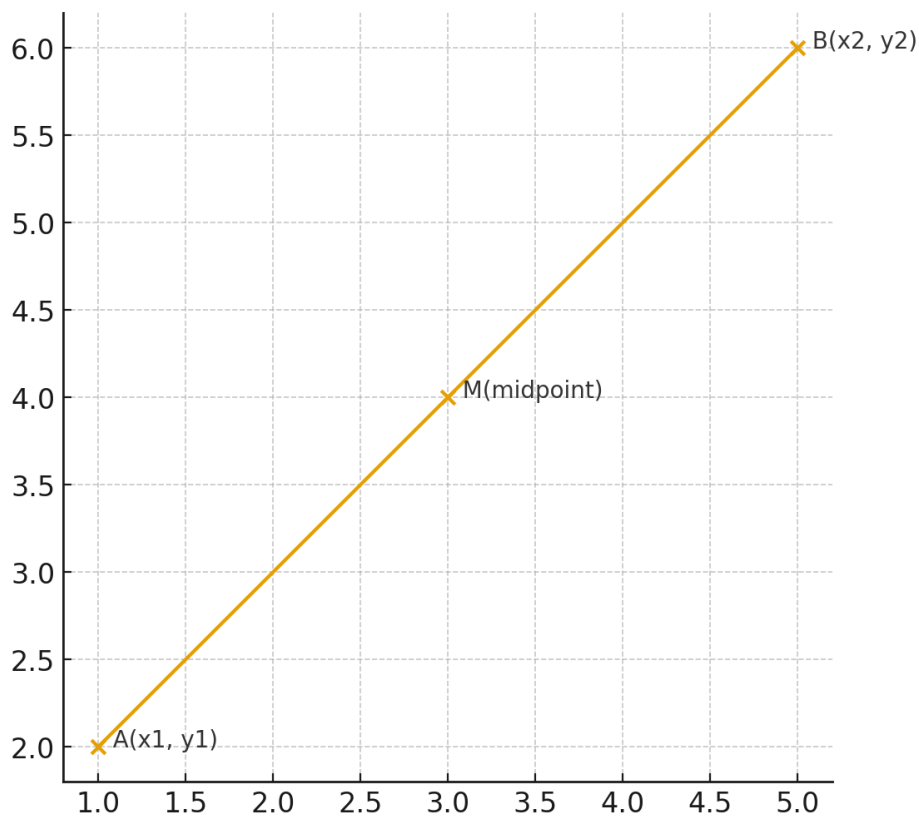
### Midpoint of a Line Segment

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

#### Midpoint Formula

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

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



### Section Formula

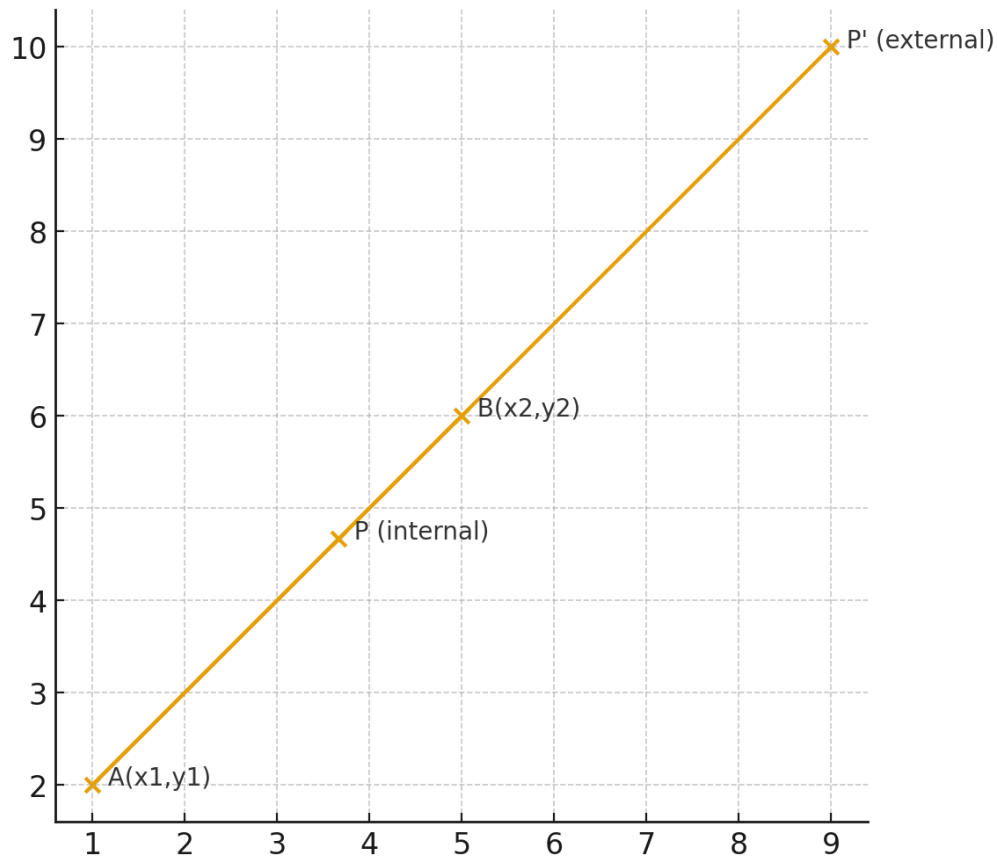
- If a point  $P$  divides the line segment joining  $A(x_1, y_1)$  and  $B(x_2, y_2)$  in the ratio  $m : n$ :

#### Internal Division

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

#### External Division

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



- 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

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

- 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

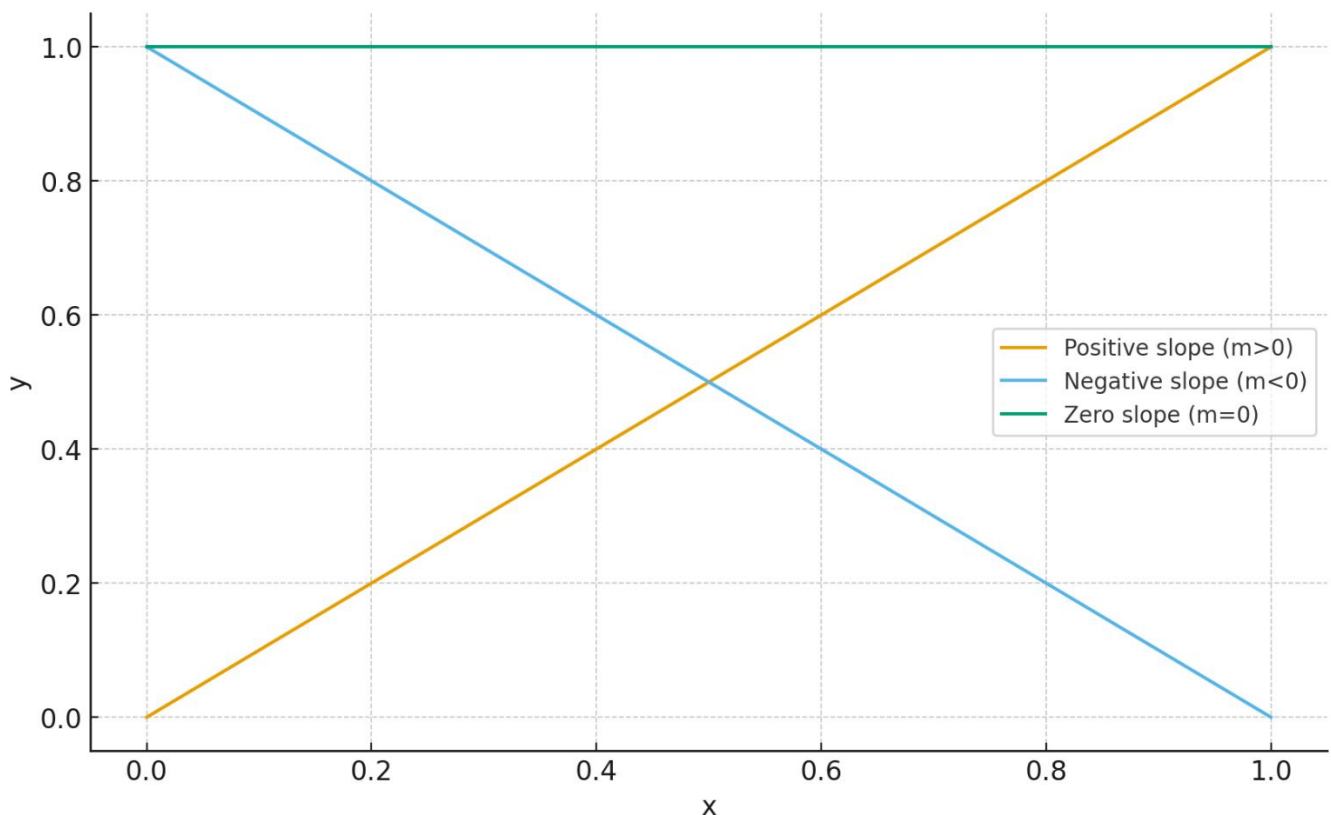
### Definition of Slope (Gradient)

- 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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