14 Line Graphs

Expected Learning Outcomes

At the end of the chapter, learners will be able to:

- **Plot** a point on a coordinate plane given its coordinates.
- **Create** a line graph to represent the relationship between two sets of data.
- **Analyse** a line graph to identify the trends or patterns in the data it represents.

Coordinate Axes

Coordinates are used in mathematics to describe the position of a point. In a graph-paper draw two mutually perpendicular straight lines X'OX and YOY', intersecting each other at the point O. These lines are known as *coordinate axes*.

The plane containing both coordinate axes is called the Cartesian plane. On the X-axis, the left and right sides of the origin represent negative and positive real numbers respectively. On the Y-axis, the downward and upward directions from the origin represent negative and positive real numbers respectively, as shown in Fig. 14.1.

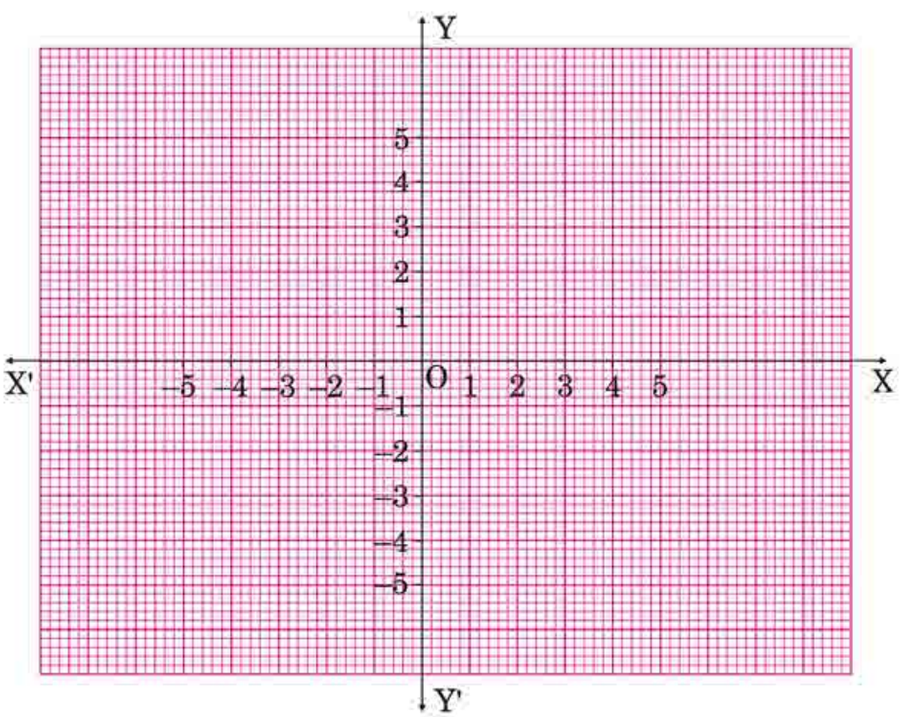


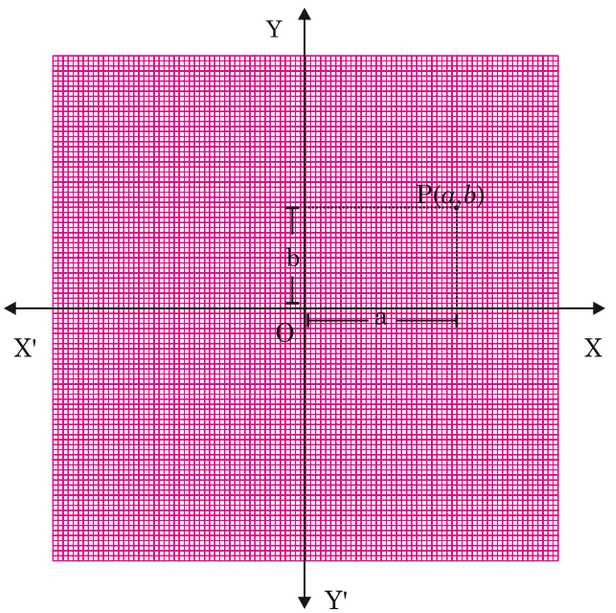
Fig. 14.1

Ordered pair: A pair of two numbers say p and q, listed in a specific order, is called an *ordered pair* (p, q); with p at the first place and q at the second place.

Remember that $(p, q) \neq (q, p)$. Thus, $(3, 4) \neq (4, 3)$.

Coordinates of a Point

On a graph paper, let X'OX and Y'OY be the coordinate axes. Let P be a point on the graph paper such that P is at a distance of a unit from the y-axis and b unit from the x-axis. Then, we say that the coordinates of P are P (a, b).



Remember

- XOY and YOX represent the same region. This is similar for other quadrants as well.

Fig. 14.2

Here a is called the x-coordinate or **abscissa** of P, while b is called the y-coordinate or **ordinate** of P.

Quadrants: The coordinate axes divide the plane of the graph paper into four regions, known as quadrants.

Region	Quadrant	Sign of coordinates
XOY	I	(+, +)
YOX'	II	(–, +)
X'OY'	III	(–, –)
Y'OX	IV	(+, –)

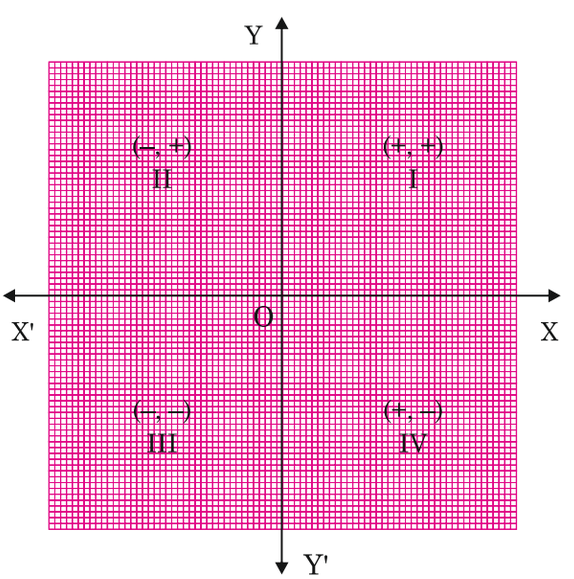


Fig. 14.3

Let's consider these examples:

Example 1: **Plot the following points on a graph paper.**

(i) A (3, 6) (ii) B (–1, 5) (iii) C (–2, –4) (iv) D (3, –3)

Solution: Let X'OX and YOY' be the coordinate axes. Then the given four points may be plotted as given:

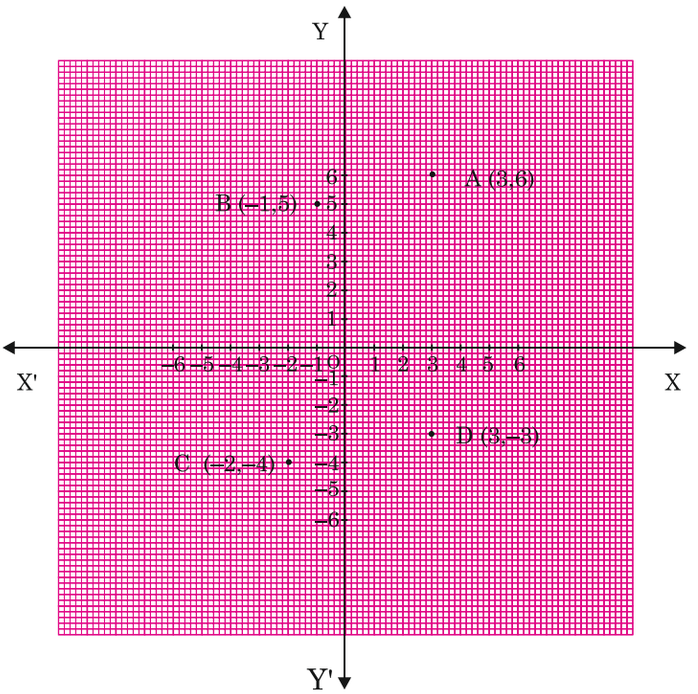


Fig. 14.4

(i) For point A(3, 6): On the X-axis, move 3 units to the right of the origin. From there, move 6 units up parallel to the Y-axis.

(ii) For point B(–1, 5): On the X-axis, move 1 unit to the left of the origin. From there, move 5 units up parallel to the Y-axis.

(iii) For point C(–2, –4): On the X-axis, move 2 units to the left of the origin. From there, move 4 units down parallel to the Y-axis.

(iv) For point D(3, –3): On the X-axis, move 3 units to the right of the origin. From there, move 3 units down parallel to the Y-axis.

Plot each point at the end of these movements.

Example 2 : **On a Cartesian plane, plot the points A (–3, 2), B (0, 5) and C (3, 2). Join them, which figure do you get?**

Solution: On joining the points A, B and C, we get the triangle ABC.

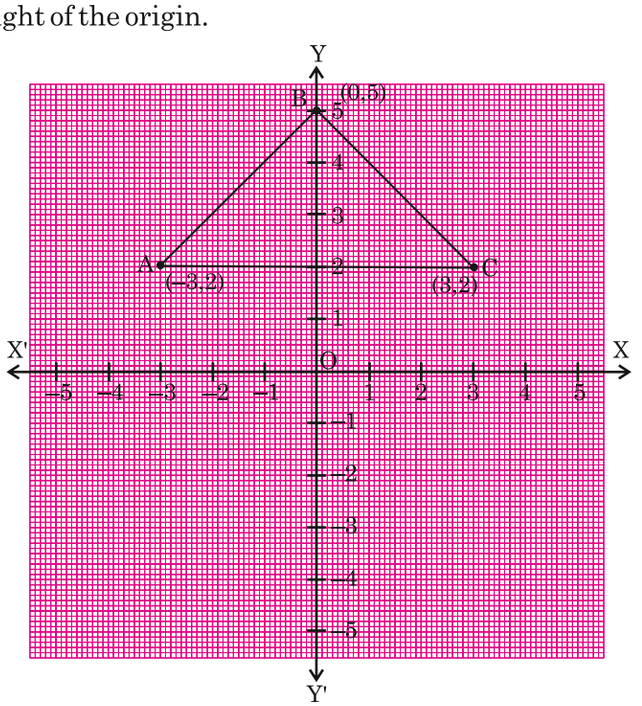


Fig. 14.5

Line Graphs and its applications

Line Graphs

A line graph is a type of chart used to display data that changes over time. It uses points connected by lines to show how data values change.

Difference between Linear Graph and Line Graph

A linear graph always shows a straight line, representing a linear relationship between variables.

A line graph can show any shape, including straight lines, curves, or zigzags.

Linear graphs are indeed a specific type of line graph. All linear graphs are line graphs, but not all line graphs are linear.

Applications

Line graphs are used in many areas, such as:

(i) Speed and time

(ii) Time and simple interest

(iii) Time and distance

(iv) Population growth over time

Remember

- In line graphs, the X-axis usually represents the independent variable, such as days or temperature, while the Y-axis shows the dependent variable like the amount of rainfall or the price of an item.

Example 3: **Draw the graph of the equation $y = 3x$ and from the graph, find the value of y, when $x = 3.5$.**

Solution: The given equation is $y = 3x$.

For different values of x, the corresponding values of y will be as given below:

x	0	2	3	4
$y = 3x$	0	6	9	12

On a graph paper, plot the points O (0, 0), A (2, 6), B (3, 9) and C (4, 12). Join them successively to obtain the required graph.

Reading off from the graph:

On the X-axis, take the point P at $x = 3.5$.

Draw PQ $\perp$ X-axis, meeting the graph at Q.

Clearly, PQ = 10.5 units.

$\therefore$ $x = 3.5 \Rightarrow$ A = 10.5.

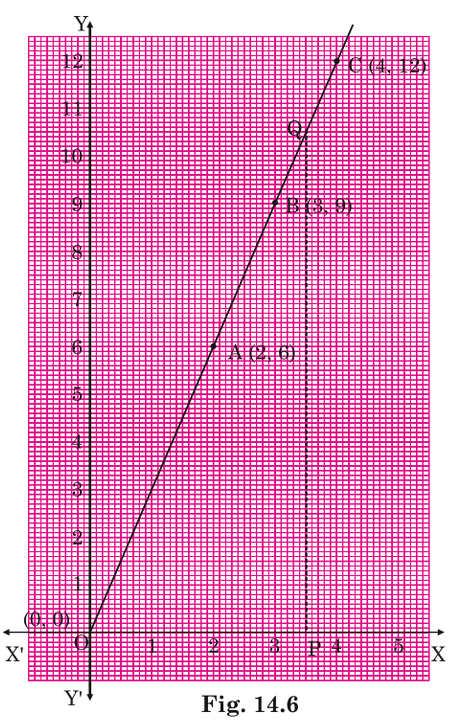


Fig. 14.6

Example 4: **We know that the perimeter of a square is given by the formula P = 4s. Here, P = perimeter and s = length of side.**

(i) Draw a graph of this formula by taking various values of s.

(ii) From the graph, find the value of P, when $s = 4$.

Solution: (i) The given function is P = 4s. For different values of s, the corresponding values of P are given below:

s	0	1	2	3
P = 4s	0	4	8	12

On a graph paper, plot the points O (0, 0), P (1, 4), Q (2, 8) and R (3, 12). Join these points to get the required graph line as shown on the right side.

(ii) **Reading off from the graph**

On the x-axis, take the point A at $s = 4$.

Draw AB $\perp$ x-axis, meeting the graph at B.

Clearly, AB = 16 units.

$\therefore$ $s = 4 \Rightarrow P = 16$.

Thus, when s = 4, then P = 16.

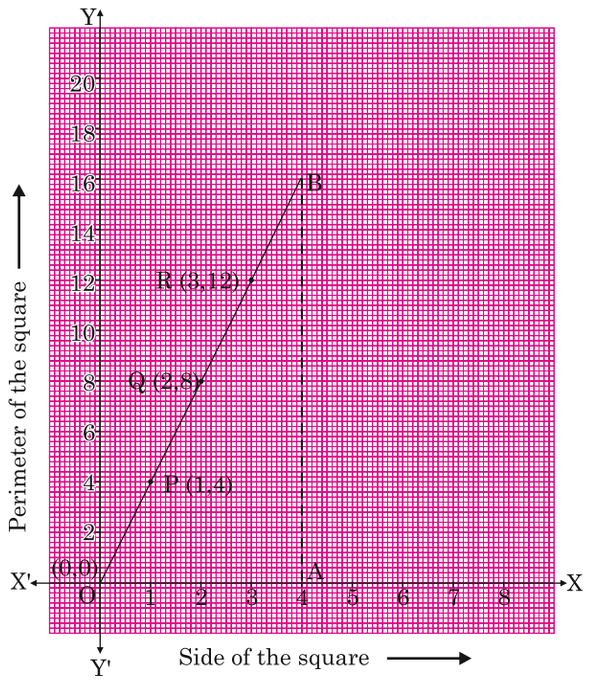


Fig. 14.8

Example 5: **Suppose simple interest on a certain sum is ₹ 50 per year.**

Then simple interest, I = 50 × t, where t is the number of years.

(i) Write the ordered pairs (t, I) for drawing the graph.

(ii) Draw a graph of this function with t along X-axis and I along Y-axis.

(iii) From the graph, find the value of I, when t = 4.

(iv) Making use of the graph find t when I = ₹ 250.

Solution: (i) The given function is I = 50 × t or 50t

Putting t = 0, 1, 2, 3 successively in the function, we find the corresponding value of I as given in the table.

t	0	1	2	3
I = 50t	0	50	100	150

(ii) Let us choose scale as under follows.
Along the X-axis: 1 small square = 1 unit.

Along the Y-axis: 1 small square = 25 units.

Now, on a graph paper, plot the points O (0, 0), L (1, 50), M (2, 100) and N (3, 150) and join them successively.

We get the required graph as shown below.

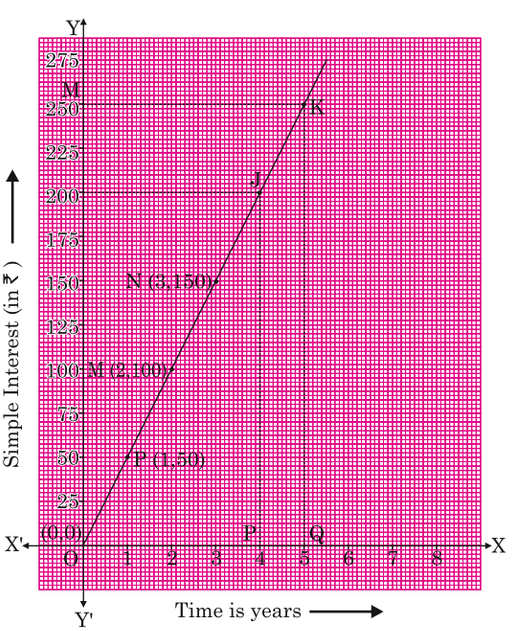


Fig. 14.9

Reading off from the graph

(iii) On the X-axis, take the point J at t = 4.

Draw PJ $\perp$ X-axis, meeting the graph at J. Clearly, PJ = 200 units.

$\therefore$ $t = 4$ years $\Rightarrow$ I = ₹ 200.

Thus, when $t = 4$ years, then I = ₹ 200

(iv) On the Y-axis, take the point M at I = ₹ 250 and extend it to meet the graph at K.

Draw QK $\perp$ x-axis, meeting the graph at K. Clearly, QK = 5 years.

$\therefore$ I = ₹ 250 $\Rightarrow$ $t = 5$ years.

Thus, when I = ₹ 250, time period = 5 years.

Example 6: Observe the following graph:

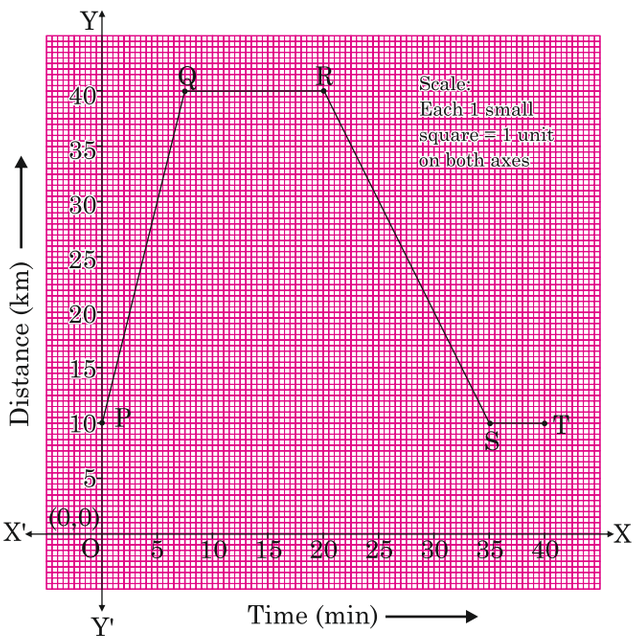


Fig. 14.10

(i) What is the speed of the object in 10th minute?

(ii) When is the speed of the object zero?

(iii) Calculate speed of the object during 0–5 min.

Solution: (i) The graph shows a horizontal line from 5 to 20 minutes, indicating a constant distance. Therefore, the speed in the 10th minute is 0 km/min (Speed = 0 km / 1 min).

(ii) The speed is zero during periods where the graph shows a horizontal line, indicating no change in distance:

Between 7.5-20 minutes

Between 35-40 minutes

(iii) Change in time = 5 minutes

Change in distance = 20 km (30 km - 10 km)

$$\text{Speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{30\,\text{km}}{5\,\text{min}} = 6\,\text{km/min}$$

Thus, the speed during 0-5 minutes is 6 km/min.

Exercise 14.1

1. (i) Draw the graph of the function $A = s^2$.

(ii) From the graph, find the value of A, when

(a) $s = 2$ (b) $s = 3$ (c) $s = 4$

2. (i) Draw the graph of the function $y = 4x$.

(ii) From the graph, find the value of y, when

(a) $x = 2$ (b) $x = -2$ (c) $x = 3$

3. Copy and complete the table of values of each equation. Hence, draw the respective graphs:

(i) $x = y + 8$

x				
y	0	3	5	–2

(ii) $y = x - 4$

x	2	5	–6	–4
y				

4. In the following distance-time graph of a car, find:

(i) Speed between 0 to 5 minutes.

(ii) At what time interval speed is zero?

(iii) At what time, the speed is highest?

(iv) Total distance travelled by the body in 20 minutes.

[**Hint :** For the total distance, add the distance from 0 to 10 minutes, then from 10 to 15 minutes, and since no distance is travelled from 15 to 20 minutes, consider it 0.]

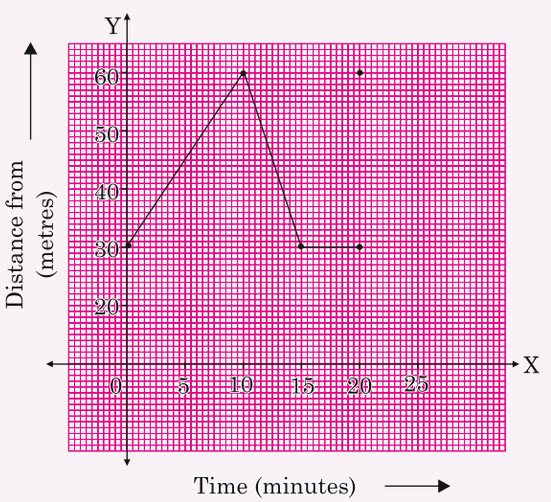


Fig. 14.11

5. The graph given below shows the number of books sold by a shopkeeper between the month February to June.

(i) In which month was the sale of books highest?

(ii) In which month was the sale of books minimum?

(iii) How many books were sold in different months?

Fig. 14.12

6. Interest on deposits for a year is given in the following table:

Deposit (in ₹)	1,000	2,000	3,000	4,000	5,000
Simple Interest (in ₹)	90	180	270	360	450

Draw the graph for the above table. Now, answer the following questions:

(i) Does the graph pass through the origin ?

(ii) Use the graph to find the interest on ₹ 3,500 for a year.

7. Study the following graph carefully and answer the following questions.

Find:

(i) Change in y when x changes from 0 to 2.

(ii) Change in y when x changes from 2 to 6.

(iii) Change in y when x changes from 6 to 8.

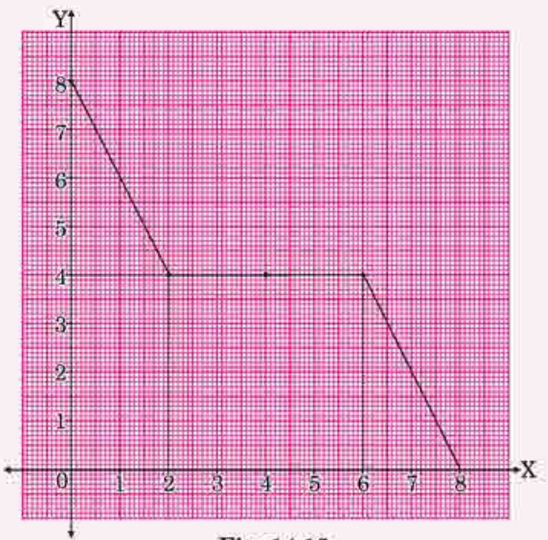


Fig. 14.13

8. Consider the formula D = 5t, where D is variable for the distance that a shuttle travelled in 't' seconds of time:

(i) Use the formula to complete the table of values given below:

t (in sec.)	0	1	2	3	4			10
D (in metre)	0	5				25	35	

(ii) Draw graph of the formula D = 5t, choosing the horizontal axis as the t-axis.

(iii) From the above graph, find the distance covered by the shuttle in 5 seconds and 7 seconds.

(iv) Using the graph find the time taken by the shuttle in covering a distance of 15 metres and 45 metres.

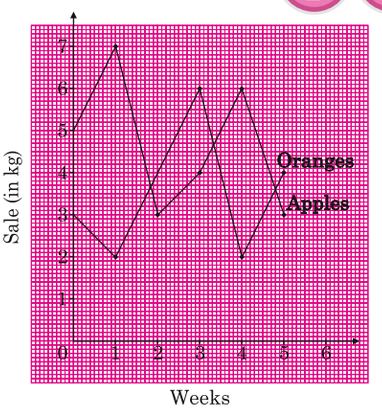
9. The area A of a triangle of base b units, height h units is $\frac{1}{2} \times b \times h$ square units. If the base is held constant at 15 cm, graph the relationship between A and h.

10. Draw the graph between simple interest versus time on amount of ₹ 10,000 at a rate of interest 10% per annum.

Teacher's Note

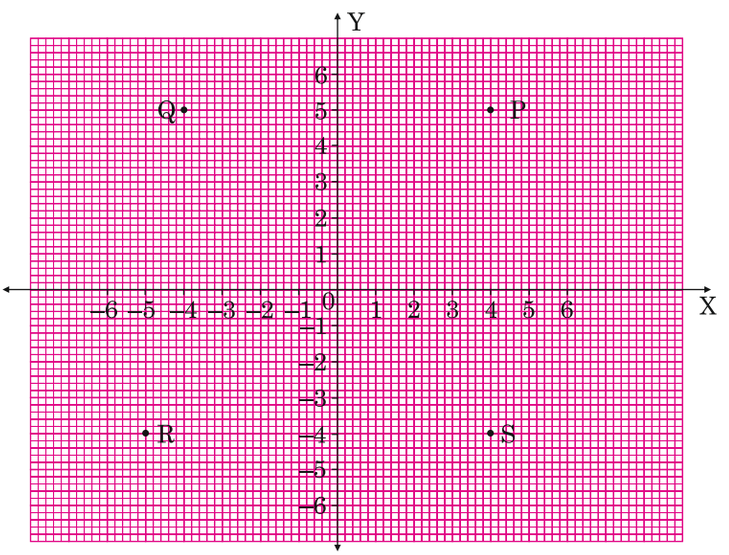
Encourage students to relate line graphs to real life examples, such as tracking daily temperatures, or pocket money saved over time. This makes the concept more engaging and helps them understand trends easily. Also remind them to label axes properly and scale them consistently for clarity.

1. Plot the points A (3,3), B (7,3), C (7,6) and D (3,6).
   Join A to B, B to C, C to D and D to A. What shape is the quadrilateral ABCD? Find its perimeter and area.
2. Write the coordinates of any three points on the X-axis, at least one of which lies to the left of origin.
3. A shopkeeper sold number of apples and oranges in different weeks. The results are shown by the following graph.



   Answer the following questions:
   (i) How many apples are sold in week 4?
   (ii) How many oranges are sold in week 3 and week 5 together?

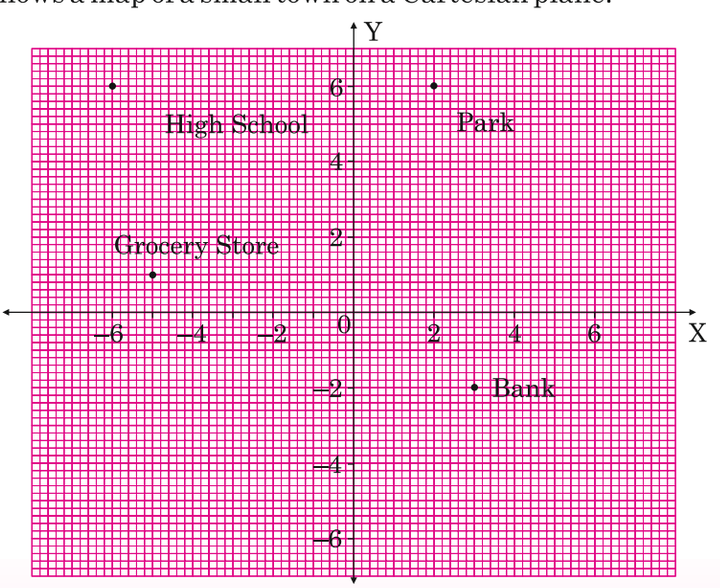
4. Write the coordinates of the points P, Q, R and S shown in the Cartesian plane below:



5. Draw the graph of distance covered by a car in a different time.

Time	0	1	2	3	4	5
Distance	0	5	12	20	28	35

6. The following graphs shows a map of a small town on a Cartesian plane.



Find the coordinates of the following:

(a) High School (b) Bank (c) Grocery Store (d) Park

Also write which quadrant each of these places belong to.

7. Given below is a table of the stretch of a spring in a balance. Draw a graph on the basis of this table.

Stretch (in cm)	0.5	1	1.5	2
Weight (in g)	200	400	600	800

Key Insights

1. Coordinate System Basics: The Cartesian plane features two perpendicular axes (X-axis and Y-axis) intersecting at the origin (O), where each point is represented by an ordered pair (p, q).
2. Quadrants and Their Signs: The plane is divided into four quadrants:
   Quadrant I: (+, +) - both coordinates are positive. Quadrant II: (–, +) - X is negative, Y is positive.
   Quadrant III: (–, –) - both coordinates are negative. Quadrant IV: (+, –) - X is positive, Y is negative.
3. Plotting Points: To plot a point, move along the X-axis first (left or right based on the sign) and then along the Y-axis (up or down based on the sign) to locate the point accurately.
4. Line Graph: Line graphs connect data points with lines to illustrate trends and changes over time, making them effective for visualising relationships between variables.

HOTS

1. A sum of ₹5,000 is deposited in a bank at the rate of 10% simple interest. Plot a line graph with interest and number of years as variables.
2. In square, the perimeter is four times the side of a square. Make a table of ordered pairs (X,Y) and plot the line graph where X = length and Y = perimeter.
3. The area of a triangle is 64 cm^2. There are two variables: the base of the triangle and the height of the triangle. Make a table of ordered pairs as (base, height) and plot the line graph. If the area of the triangle remains constant what happens to the height in the following cases:
   a. When the base increases. b. When the base decreases.

CROSS-CURRICULAR CONNECT

SDG 4

In 1947, 82% of India's population couldn't read or write. But by 2018, the literacy rate soared to 77.7%, helping the country grow economically and socially. Literate individuals got better jobs, took part in democracy, and used technology. Health improved too. However, challenges like gender inequality and uneven education quality remained. Despite this, India's progress in literacy inspiring, Continuous efforts are needed for everyone to read and write, unlocking India's full potential.

With the given data on literacy rates of India over different years, create a line graph using it.

Decade	1950s	1960s	1970s	1980s	1990s	2000s	2010s
Literacy rate (%)	18	28	34	44	52	65	74

What steps should the government take to increase the litearcy rate?

Maths Lab Activity

Objective: To interpret data by plotting a line graph that shows the relationship between child's age and clothing size.

Materials Required: Graph paper, pencil, and sketch pen

Procedure:

Step 1: Draw the x-axis (Age of Child) and y-axis (Clothes Size) on graph paper.

Step 2: Label the x-axis as "Age of Child (years)" and the y-axis as "Clothes Size (number)".

Step 3: Choose a scale: 1 unit = 1 year on x-axis and 1 unit = 10 clothes size on y-axis.

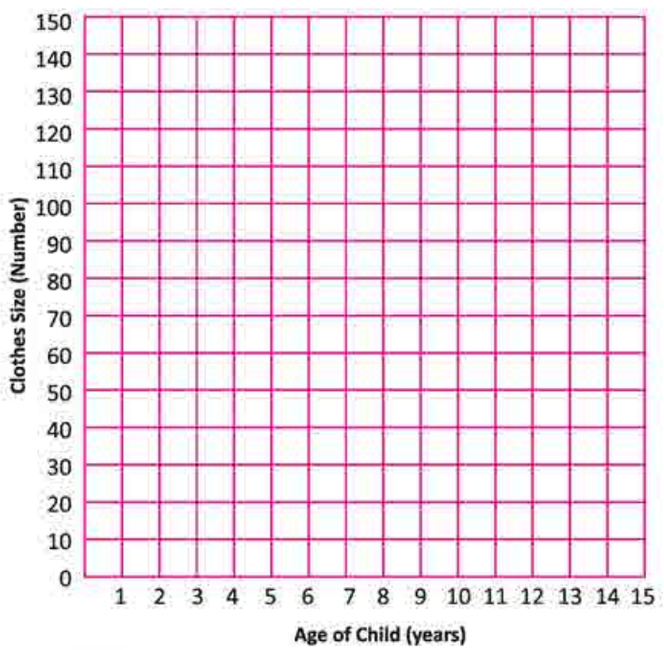
Step 4: Plot the data points: (1, 15), (2, 20), (3, 25), (5, 35), (7, 50), (9, 75), (12, 100).

Step 5: Connect the points with straight lines to form the graph.

Step 6: Use a sketch pen to trace the lines for clarity.

Step 7: Add the title "Clothing Size for Different Ages of Children" at the top.

Note: You must draw the graph here by yourself.



Age of child (years)	Clothe size (number)
1	15
2	20
3	25
5	35
7	50
9	75
12	100

Project Work

Collect data on daily shoe sales from a local shopkeeper for one week. Create a table with days (Monday to Sunday) and corresponding sales figures. Use GeoGebra to make a line graph: plot days on the x-axis and sales on the y-axis. Add a title and appropriate scales. Analyse your graph for daily trends and patterns.

If you were the shop owner, what changes would you consider making to the shop's opening hours based on the sales data?