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SOLUTIONS BOOK

CLASS 9

Mathematics · Ganita Manjari

CHAPTER 2

Introduction to Linear Polynomials

Complete Exercise Solutions

Exercise Sets 2.1 – 2.6 · End-of-Chapter

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IT

CLASS 9 MATHS · GANITA MANJARI · CHAPTER 2

In-Text Questions

Think and Reflect · questions inside the running text

Directions: These are the questions that appear inside the running text of the chapter (the *Think and Reflect* boxes and the "Can you guess …?" prompts). Each is answered below in the order in which it appears; the page number of the chapter is given with every question.

IN-TEXT 1 · P. 17

Think and Reflect (Example 2: total cost = 200*l* + 160*w* + 50*lw*)

1. Can you identify the terms, variables and coefficients of this algebraic expression?

2. How is it different from the algebraic expression in Example 1?

ANSWER

1 Terms, variables, coefficients

Terms: 200*l*, 160*w* and 50*lw*. **Variables:** *l* and *w*. **Coefficients:** 200 (of *l*), 160 (of *w*) and 50 (of *lw*). There is no constant term.

2 Difference from Example 1 (4x + 5y + 3)

Both expressions have two variables. But in Example 1 every term has only one variable (powers 1), and there is a constant term 3. Here the term 50*lw* contains *both* variables multiplied together (it is of degree 2), and there is no constant term.

Therefore, 200l + 160w + 50lw has the product term 50lw, which 4x + 5y + 3 does not have.

IN-TEXT 2 · P. 17

Think and Reflect (Example 3: area = $10x - x^2$)

1. Can you identify the terms, variables and coefficients of this algebraic expression?

2. Can you point out any similarity or difference between the algebraic expressions obtained in Examples 1 and 3?

ANSWER

1 Terms, variables, coefficients

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Terms: $10x$ and $-x^2$. **Variable:** x. **Coefficients:** 10 (of x) and –1 (of x^2). There is no constant term.

2 Examples 1 and 3

Similarity: both are sums of terms, each term being a number times a power of a variable.
Differences: Example 1 ($4x + 5y + 3$) has two variables and the highest power of each is 1, with a constant term. Example 3 has only one variable x, whose highest power is 2, and no constant term.

Therefore, $10x - x^2$ is a one-variable expression of degree 2, while $4x + 5y + 3$ has two variables and degree 1.

IN-TEXT 3 · P. 19

Think and Reflect. Find the perimeter of squares with sides 1 cm, 1.5 cm, 2 cm, 2.5 cm and 3 cm. What will happen to the perimeters if the sides increase by 0.5 cm?

ANSWER

Perimeter of a square of side x is $4x$.

Side (cm)	1	1.5	2	2.5	3
Perimeter (cm)	4	6	8	10	12

Each time the side increases by 0.5 cm, the perimeter increases by $4 \times 0.5 = 2$ cm.

Therefore, the perimeters are 4, 6, 8, 10 and 12 cm, and they increase by a constant 2 cm for every 0.5 cm increase in the side.

IN-TEXT 4 · P. 19

Think and Reflect. If a player paid ₹750, how many matches did he play?

ANSWER

The amount paid for m matches is ₹$(200 + 50m)$. Put $200 + 50m = 750$.

$$50m = 750 - 200 = 550$$
$$m = 550 \div 50 = 11$$

Therefore, the player played 11 matches.

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IN-TEXT 5 · P. 20

Think and Reflect. We have learnt that to evaluate the value of an algebraic expression, we substitute a value of the variable in the given expression. Consider Example 3, where the wire is bent to form a rectangle. Here, the area of the rectangle, $10x - x^2$, is a function of x. Can you interpret this as an input-output process? What value does the expression take when $x = 6$ cm?

ANSWER

Input: the length x of the rectangle (in cm). **Process:** compute $10x - x^2$. **Output:** the area of the rectangle (in cm²). For every length x (between 0 and 10) there is exactly one area.

For $x = 6$: $10 \times 6 - 6^2 = 60 - 36 = 24$.

Check: the width is $10 - 6 = 4$ cm, and the area is $6 \times 4 = 24$ cm².

Therefore, the expression takes the value 24 cm² when x = 6 cm.

IN-TEXT 6 · P. 22

Think and Reflect. Predict the number of squares in the next three stages of the pattern and write the sequence of numbers up to Stage 7 of the pattern.

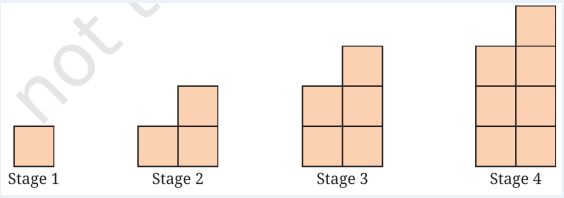


Fig. 2.4

ANSWER

Each stage has 2 more tiles than the stage before. Stage 4 has 7 tiles, so:

Stage	1	2	3	4	5	6	7
Number of tiles	1	3	5	7	9	11	13

Therefore, the next three stages (5, 6, 7) have 9, 11 and 13 squares, and the sequence is 1, 3, 5, 7, 9, 11, 13.

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IN-TEXT 7 · P. 22

Think and Reflect. Using the expression $2n - 1$, can you find out how many tiles will be there in the 15th stage and the 26th stage of the pattern? Also, which stage will contain 21 tiles and 47 tiles?

ANSWER

a **15th and 26th stage**

$n = 15$: $2 \times 15 - 1 = 29$
$n = 26$: $2 \times 26 - 1 = 51$

b **Stage with 21 tiles and 47 tiles**

$2n - 1 = 21 \Rightarrow 2n = 22 \Rightarrow n = 11$
$2n - 1 = 47 \Rightarrow 2n = 48 \Rightarrow n = 24$

Therefore, the 15th and 26th stages have 29 and 51 tiles; the 11th stage has 21 tiles and the 24th stage has 47 tiles.

IN-TEXT 8 · P. 23

Think and Reflect. What amount will be left on the 15th day? How many days will it take for the entire amount to be spent?

ANSWER

Amount left on the nth day is ₹$(100 - 5n)$.

$n = 15$: $100 - 5 \times 15 = 100 - 75 = 25$
$100 - 5n = 0 \Rightarrow n = 20$

Therefore, ₹25 will be left on the 15th day, and the entire amount will be spent in 20 days.

IN-TEXT 9 · P. 23

Think and Reflect. For how many km will the fare be ₹130?

ANSWER

The fare for n km ($n \geq 2$) is ₹$(15n - 5)$. Put $15n - 5 = 130$.

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$$15n = 135$$
$$n = 9$$

Check: 25 + 15 × (9 – 2) = 25 + 105 = 130 ✓.

Therefore, the fare is ₹130 for 9 km.

IN-TEXT 10 · P. 24

Think and Reflect. What is the cost for travelling 15 km? For how many kilometres will the cost of the journey be ₹700?

ANSWER

The cost function is $C(d) = 100 + 60d$.

$$C(15) = 100 + 60 \times 15 = 100 + 900 = 1000$$
$$100 + 60d = 700 \Rightarrow 60d = 600 \Rightarrow d = 10$$

Therefore, the cost for 15 km is ₹1000, and the cost is ₹700 for 10 km.

IN-TEXT 11 · P. 25

Think and Reflect. What will be the height of the water at the end of 5 months?

ANSWER

$h(t) = 3 – 0.5t$, so $h(5) = 3 – 0.5 \times 5 = 3 – 2.5 = 0.5$.

Therefore, the height of the water will be 0.5 m at the end of 5 months.

IN-TEXT 12 · P. 27

Think and Reflect. Can you guess what the numbers 20 and 150 in the equation $y = 20x + 150$ represent?

ANSWER

y is the monthly bill in ₹ and x is the number of GB used.

20 is the extra cost per GB of data: the bill increases by ₹20 for every additional GB (it is the slope). **150** is the fixed monthly fee, the bill when no data is used ($x = 0$); it is the y-intercept.

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Therefore, 20 is the charge per GB and 150 is the fixed monthly fee (in rupees).

IN-TEXT 13 · P. 28

Think and Reflect. Identify other points on the line by completing the following table (the line is $y = 2x + 1$).

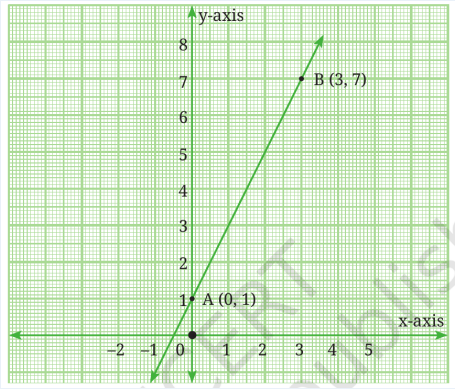


Fig. 2.5

ANSWER

Use $y = 2x + 1$ for each value of x:

x	1	2	5	7	9	12	20
y	3	5	11	15	19	25	41

For example, $x = 5$ gives $2 \times 5 + 1 = 11$; $x = 20$ gives $2 \times 20 + 1 = 41$.

Therefore, the points (1, 3), (2, 5), (5, 11), (7, 15), (9, 19), (12, 25) and (20, 41) lie on the line.

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IN-TEXT 14 · P. 28-29

Example 12. ... Can you guess the equation of this line by looking at the relationship between the *x* and *y* coordinates of each point? (Points (–1, –3), (0, 0), (1, 3), (3, 9), (4, 12).)

Example 13. ... Can you guess the equation of this line by looking at the relationship between the *x* and *y* coordinates of each point? (Points (–3, 6), (–2, 4), (0, 0), (1, –2), (2, –4), (3, –6).)

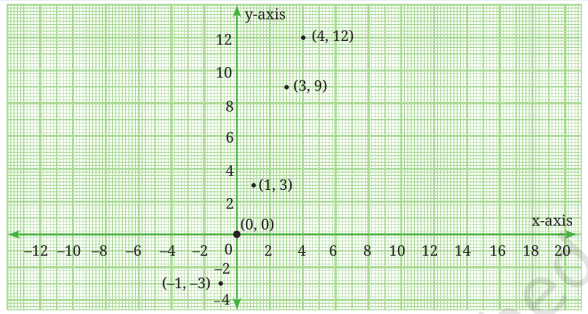


Fig. 2.6

ANSWER

12 Example 12

In every point the *y*-coordinate is 3 times the *x*-coordinate: –3 = 3 × (–1), 0 = 3 × 0, 3 = 3 × 1, 9 = 3 × 3, 12 = 3 × 4.

13 Example 13

In every point the *y*-coordinate is –2 times the *x*-coordinate: 6 = –2 × (–3), 4 = –2 × (–2), 0 = –2 × 0, –2 = –2 × 1, –4 = –2 × 2, –6 = –2 × 3.

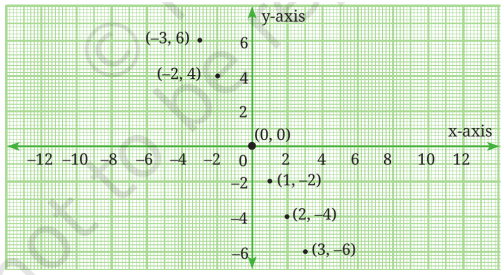


Fig. 2.7 (Example 13)

Therefore, the lines are y = 3x (Example 12) and y = –2x (Example 13).

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IN-TEXT 15 · P. 31

Fig. 2.9 shows all the three graphs on the same axes. Does this help you to conclude anything about the linear equation $y = ax$, $a > 0$ as a varies? What happens when $a > 1$ and when $a < 1$? (Hint: You may also plot the equations $y = 3x$ and $y = (1/3)x$ on the same axes.)

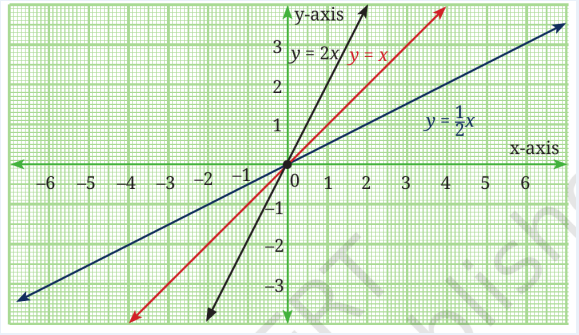


Fig. 2.9

ANSWER

All the lines $y = ax$ pass through the origin (0, 0) and rise from left to right ($a > 0$).

When a > 1 (for example $y = 2x$, $y = 3x$), the line is **steeper** than $y = x$: y grows faster than x. The larger a is, the steeper the line.

When a < 1 (for example $y = ½x$, $y = ⅓x$), the line is **less steep** than $y = x$, closer to the x-axis. The smaller a is, the flatter the line.

The line $y = x$ ($a = 1$) is equally inclined to both axes.

Therefore, the number a is the slope; a larger slope means a steeper line.

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IN-TEXT 16 · P. 33

Fig. 2.11 shows all the three graphs on the same axes. Does this help you to conclude anything about the linear equation $y = -ax$, $a > 0$, as a varies? What will happen when $a > 1$ and when $a < 1$?

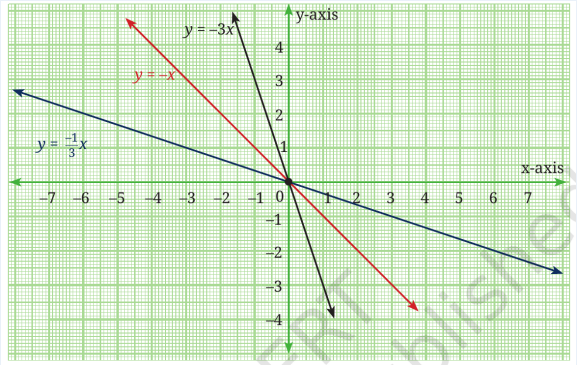


Fig. 2.11

ANSWER

All the lines $y = -ax$ pass through the origin and fall from left to right (negative slope $-a$).

When a > 1 (for example $y = -3x$), the line is steeper than $y = -x$. **When a < 1** (for example $y = -\frac{1}{3}x$), the line is less steep than $y = -x$. The steepness depends on the size of a; the line $y = -x$ is equally inclined to both axes.

Therefore, y = –ax slopes downward and is steeper when a is larger, exactly as y = ax is steeper for larger a.

IN-TEXT 17 · P. 33

Think and Reflect. Differentiate between the graphs of the equations $y = 3x + 1$, and $y = -3x + 1$.

ANSWER

Both lines have the same y-intercept 1: both cut the y-axis at (0, 1).

$y = 3x + 1$ has slope 3 (positive): it rises from left to right and represents linear growth; it cuts the x-axis at (–1/3, 0). $y = -3x + 1$ has slope –3 (negative): it falls from left to right and represents linear decay; it cuts the x-axis at (1/3, 0).

They are equally steep (the size of the slope is 3 in both) and are mirror images of each other in the y-axis.

Therefore, the graphs differ in the sign of the slope: one rises and the other falls, and both pass through (0, 1).

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IN-TEXT 18 · P. 35

Think and Reflect. Does this help you to conclude anything about the linear equation $y = ax + b$ when a is fixed but b varies? (Hint: In these equations $a = 2$, and b takes the values –1, 1 and 5, respectively.)

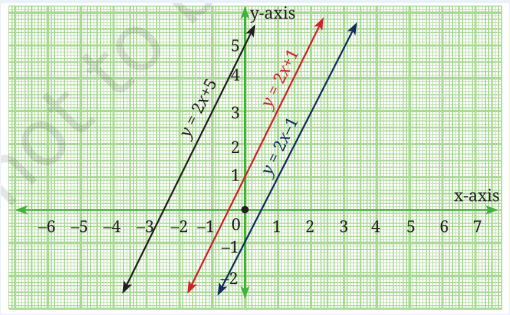


Fig. 2.13

ANSWER

In Fig. 2.13 the lines $y = 2x - 1$, $y = 2x + 1$ and $y = 2x + 5$ all have the same slope 2, and they cut the y-axis at (0, –1), (0, 1) and (0, 5).

So, when a is fixed and b changes, the line is **shifted up or down** (by the change in b) but remains **parallel** to the original line. Lines with equal slopes and different y-intercepts are parallel.

Therefore, changing b moves the line parallel to itself; b is the y-intercept.

IN-TEXT 19 · P. 29

Example 14. Draw the graphs of $y = \frac{1}{2}x$, $y = x$, $y = 2x$ by selecting suitable points on these lines. (Hint: In order to graph $y = \frac{1}{2}x$, we could take the points (0, 0) and (4, 2). Can you verify that these lie on the line?)

ANSWER

Verification. For (0, 0): $\frac{1}{2} \times 0 = 0$ ✓. For (4, 2): $\frac{1}{2} \times 4 = 2$ ✓. Both points satisfy $y = \frac{1}{2}x$, so they lie on the line.

Line	Two points on it
y = ½x	(0, 0) and (4, 2)
y = x	(0, 0) and (2, 2)
y = 2x	(0, 0) and (1, 2)

Plot the two points of each line and join them with a ruler, extending the line in both directions (Fig. 2.8 and Fig. 2.9).

Therefore, each line passes through the origin; the steepness increases with the coefficient of x.

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2.1

CLASS 9 MATHS · GANITA MANJARI · CHAPTER 2

Exercise Set 2.1

Solutions · 5 questions

QUESTION 1

Find the degrees of the following polynomials:

(i) $2x^2 - 5x + 3$

(ii) $y^3 + 2y - 1$

(iii) -9

(iv) $4z - 3$

ANSWER

The degree of a polynomial is the highest power of the variable.

i **$2x^2 - 5x + 3$**

Highest power of x is 2.

ii **$y^3 + 2y - 1$**

Highest power of y is 3.

iii **-9**

It is a constant polynomial: $-9 = -9x^0$, so the degree is 0.

iv **$4z - 3$**

Highest power of z is 1.

Therefore, the degrees are (i) 2, (ii) 3, (iii) 0, (iv) 1.

QUESTION 2

Write polynomials of degrees 1, 2 and 3.

ANSWER

Any polynomials with the required highest power will do. For example:

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Degree 1: 3x + 5
Degree 2: x^2 – 4x + 7
Degree 3: $2x^3 + x^2 – 6$

Therefore, 3x + 5, x^2 – 4x + 7 and $2x^3 + x^2 – 6$ are polynomials of degrees 1, 2 and 3 (other answers are possible).

QUESTION 3

What are the coefficients of x^2 and x^3 in the polynomial $x^4 – 3x^3 + 6x^2 – 2x + 7$?

ANSWER

In $x^4 – 3x^3 + 6x^2 – 2x + 7$ the term with x^2 is $6x^2$ and the term with x^3 is $–3x^3$.

Therefore, the coefficient of x^2 is 6 and the coefficient of x^3 is –3.

QUESTION 4

What is the coefficient of z in the polynomial $4z^3 + 5z^2 – 11$?

ANSWER

The polynomial can be written as $4z^3 + 5z^2 + 0 \cdot z – 11$. There is no term in z.

Therefore, the coefficient of z is 0.

QUESTION 5

What is the constant term of the polynomial $9x^3 + 5x^2 – 8x –10$?

ANSWER

The constant term is the term with no variable (power 0 of x).

Therefore, the constant term is –10.

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2.2

CLASS 9 MATHS · GANITA MANJARI · CHAPTER 2

Exercise Set 2.2

Solutions · 7 questions

QUESTION 1

Find the value of the linear polynomial $5x - 3$ if:

(i) $x = 0$ (ii) $x = -1$ (iii) $x = 2$

ANSWER

i **x = 0**

$5 \times 0 - 3 = -3$

ii **x = -1**

$5 \times (-1) - 3 = -5 - 3 = -8$

iii **x = 2**

$5 \times 2 - 3 = 10 - 3 = 7$

Therefore, the values are –3, –8 and 7.

QUESTION 2

Find the value of the quadratic polynomial $7s^2 - 4s + 6$ if:

(i) $s = 0$ (ii) $s = -3$ (iii) $s = 4$

ANSWER

i **s = 0**

$7 \times 0 - 4 \times 0 + 6 = 6$

ii **s = –3**

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$$7 \times 9 - 4 \times (-3) + 6 = 63 + 12 + 6 = 81$$

iii **s = 4**

$$7 \times 16 - 4 \times 4 + 6 = 112 - 16 + 6 = 102$$

Therefore, the values are 6, 81 and 102.

QUESTION 3

The present age of Salil's mother is three times Salil's present age. After 5 years, their ages will add up to 70 years. Find their present ages.

ANSWER

Let Salil's present age be x years. Then his mother's present age is $3x$ years. After 5 years their ages are $(x + 5)$ and $(3x + 5)$.

$$(x + 5) + (3x + 5) = 70$$
$$4x + 10 = 70$$
$$4x = 60,\ x = 15$$

Mother's age = $3 \times 15 = 45$. Check: $(15 + 5) + (45 + 5) = 20 + 50 = 70$ ✓.

Therefore, Salil is 15 years old and his mother is 45 years old.

QUESTION 4

The difference between two positive integers is 63. The ratio of the two integers is 2:5. Find the two integers.

ANSWER

Let the integers be $2k$ and $5k$ (ratio 2:5). Their difference is $5k - 2k = 3k$.

$$3k = 63$$
$$k = 21$$

The integers are $2 \times 21 = 42$ and $5 \times 21 = 105$. Check: $105 - 42 = 63$ and $42 : 105 = 2 : 5$ ✓.

Therefore, the two integers are 42 and 105.

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QUESTION 5

Ruby has 3 times as many two-rupee coins as she has five rupee-coins. If she has a total ₹88, how many coins does she have of each type?

ANSWER

Let the number of five-rupee coins be x. Then the number of two-rupee coins is $3x$.

Value of five-rupee coins = 5x
Value of two-rupee coins = 2 × 3x = 6x
5x + 6x = 88
11x = 88, x = 8

Five-rupee coins = 8; two-rupee coins = 3 × 8 = 24. Check: 5 × 8 + 2 × 24 = 40 + 48 = 88 ✓.

Therefore, Ruby has 8 five-rupee coins and 24 two-rupee coins (32 coins in all).

QUESTION 6

A farmer cuts a 300 feet fence into two pieces of different sizes. The longer piece is four times as long as the shorter piece. How long are the two pieces?

ANSWER

Let the shorter piece be x feet. The longer piece is $4x$ feet.

x + 4x = 300
5x = 300, x = 60

Longer piece = 4 × 60 = 240 feet.

Therefore, the pieces are 60 feet and 240 feet long.

QUESTION 7

If the length of a rectangle is three more than twice its width and its perimeter is 24 cm, what are the dimensions of the rectangle?

ANSWER

Let the width be w cm. Then the length is $(2w + 3)$ cm. Perimeter = 2 × (length + width).

2(2w + 3 + w) = 24
3w + 3 = 12
3w = 9, w = 3

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Length = 2 × 3 + 3 = 9 cm. Check: 2 × (9 + 3) = 24 ✓.

Therefore, the rectangle is 9 cm long and 3 cm wide.

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2.3

CLASS 9 MATHS · GANITA MANJARI · CHAPTER 2

Exercise Set 2.3

Solutions · 5 questions

Directions: Solve the following.

QUESTION 1

A student has ₹500 in her savings bank account. She gets ₹150 every month as pocket money. How much money will she have at the end of every month from the second month onwards? Find a linear expression to represent the amount she will have in the *n*th month.

ANSWER

Taking ₹500 as the amount in the first month and ₹150 added in each following month:

Month	1	2	3	4	...	n
Amount (₹)	500	650	800	950	...	500 + 150(n – 1)

The amount in the nth month is $500 + 150(n - 1) = 150n + 350$. (If the first ₹150 is also counted at the end of month 1, the amount after n months is $500 + 150n$.)

Therefore, she will have ₹650, ₹800, ₹950, … from the second month, and the amount in the nth month is ₹(150n + 350).

QUESTION 2

A rally starts with 120 members. Each hour, 9 members drop out of the group. How many members will remain after 1, 2, 3, … hours? Find a linear expression to represent the number of members at the end of the *n*th hour.

ANSWER

Hour	1	2	3	4	...	n
Members left	111	102	93	84	...	120 – 9n

After 1 hour: 120 – 9 = 111; after 2 hours: 120 – 18 = 102; after 3 hours: 120 – 27 = 93; and so on.

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Therefore, 111, 102, 93, … members remain, and at the end of the nth hour there are (120 – 9n) members.

QUESTION 3

Suppose the length of a rectangle is 13 cm. Find the area if the breadth is (i) 12 cm, (ii) 10 cm, (iii) 8 cm. Find the linear pattern representing the area of the rectangle.

ANSWER

(i) $13 \times 12 = 156$ cm²
(ii) $13 \times 10 = 130$ cm²
(iii) $13 \times 8 = 104$ cm²

The area for breadth b cm is $13b$ cm². When the breadth decreases by 2 cm, the area decreases by 26 cm² every time: 156, 130, 104, ... (a constant difference of –26).

Therefore, the areas are 156, 130 and 104 cm², and the linear pattern is Area = 13b.

QUESTION 4

Suppose the length of a rectangular box is 7 cm and breadth is 11 cm. Find the volume if the height is (i) 5 cm, (ii) 9 cm, (iii) 13 cm. Find the linear pattern representing the volume of the rectangular box.

ANSWER

Base area = $7 \times 11 = 77$ cm².

(i) $77 \times 5 = 385$ cm³
(ii) $77 \times 9 = 693$ cm³
(iii) $77 \times 13 = 1001$ cm³

The volume for height h cm is $77h$ cm³. Each time the height increases by 4 cm, the volume increases by 308 cm³: 385, 693, 1001, ...

Therefore, the volumes are 385, 693 and 1001 cm³, and the linear pattern is Volume = 77h.

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QUESTION 5

Sarita is reading a book of 500 pages. She reads 20 pages every day. How many pages will be left after 15 days? Express this as a linear pattern.

ANSWER

Pages left after n days = 500 – 20n.

$$n = 15: 500 - 20 \times 15 = 500 - 300 = 200$$

Pattern: 480, 460, 440, … (after 1, 2, 3 … days), a constant decrease of 20.

Therefore, 200 pages will be left after 15 days, and the linear pattern is (500 – 20n) pages.

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2.4

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Exercise Set 2.4

Solutions · 4 questions

QUESTION 1

Suppose a plant has height 1.75 feet and it grows by 0.5 feet each month.

(i) Find the height after 7 months.

(ii) Make a table of values for *t* varying from 0 to 10 months and show how the height, *h*, increases every month.

(iii) Find an expression that relates *h* and *t*, and explain why it represents linear growth.

ANSWER

iii Expression

Height after t months = initial height + growth: $h = 1.75 + 0.5t$.

i Height after 7 months

$$h = 1.75 + 0.5 \times 7 = 1.75 + 3.5 = 5.25 \text{ feet}$$

ii Table

t (months)	0	1	2	3	4	5	6	7	8	9	10
h (feet)	1.75	2.25	2.75	3.25	3.75	4.25	4.75	5.25	5.75	6.25	6.75

iii Why linear growth

As t increases by 1 month, h increases by the fixed amount 0.5 feet. A quantity that increases by a constant amount over equal intervals shows linear growth (the line has positive slope 0.5).

Therefore, the height after 7 months is 5.25 feet and h = 1.75 + 0.5t represents linear growth.

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QUESTION 2

A mobile phone is bought for ₹10,000. Its value decreases by ₹800 every year.

(i) Find the value of the phone after 3 years.

(ii) Make a table of values for *t* varying from 0 to 8 years and show how the value of the phone, *v*, depreciates with time.

(iii) Find an expression that relates *v* and *t*, and explain why it represents linear decay.

ANSWER

iii Expression

Value after t years = 10000 – 800t (in ₹).

i Value after 3 years

$$v = 10000 - 800 \times 3 = 10000 - 2400 = ₹7600$$

ii Table

t (years)	0	1	2	3	4	5	6	7	8
v (₹)	10000	9200	8400	7600	6800	6000	5200	4400	3600

iii Why linear decay

Each year the value decreases by the fixed amount ₹800 (the slope is –800). A quantity that decreases by a constant amount over equal intervals shows linear decay.

Therefore, the phone is worth ₹7600 after 3 years and v = 10000 – 800t represents linear decay.

QUESTION 3

The initial population of a village is 750. Every year, 50 people move from a nearby city to the village.

(i) Find the population of the village after 6 years.

(ii) Make a table of values for t varying from 0 to 10 years and show how the population, P, increases every year.

(iii) Find an expression that relates P and t, and explain why it represents linear growth.

ANSWER

iii Expression

Population after t years = 750 + 50t.

i Population after 6 years

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$$P = 750 + 50 \times 6 = 750 + 300 = 1050$$

ii Table

t (years)	0	1	2	3	4	5	6	7	8	9	10
P	750	800	850	900	950	1000	1050	1100	1150	1200	1250

iii Why linear growth

Each year *P* increases by the same fixed number 50 (slope +50), so it is linear growth.

Therefore, the population after 6 years is 1050 and P = 750 + 50t represents linear growth.

QUESTION 4

A telecom company charges ₹600 for a certain recharge scheme. This prepaid balance is reduced by ₹15 each day after the recharge.

(i) Write an equation that models the remaining balance $b(x)$ after using the scheme for x days. Explain why it represents linear decay.

(ii) After how many days will the balance run out?

(iii) Make a table of values for x varying from 1 to 10 days and show how the balance $b(x)$, reduces with time.

ANSWER

i Equation

The balance after x days is $b(x) = 600 - 15x$. It reduces by a fixed ₹15 every day (negative slope –15), so it is linear decay.

ii Balance runs out

$$600 - 15x = 0$$
$$15x = 600,\ x = 40 \text{ days}$$

iii Table

x (days)	1	2	3	4	5	6	7	8	9	10
b(x) (₹)	585	570	555	540	525	510	495	480	465	450

Therefore, b(x) = 600 – 15x, the balance runs out after 40 days, and the table shows a constant decrease of ₹15 a day.

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2.5

CLASS 9 MATHS · GANITA MANJARI · CHAPTER 2

Exercise Set 2.5

Solutions · 3 questions

QUESTION 1

A learning platform charges a fixed monthly fee and an additional cost per digital learning module accessed. A student observes that when she accessed 10 modules, her bill was ₹400. When she accessed 14 modules, her bill was ₹500. If the monthly bill y depends on the number of modules accessed, x, according to the relation $y = ax + b$, find the values of a and b.

ANSWER

Substituting $(x, y) = (10, 400)$ and $(14, 500)$:

$$400 = 10a + b \quad ...(1)$$
$$500 = 14a + b \quad ...(2)$$

Subtracting (1) from (2): $100 = 4a$, so $a = 25$. From (1): $b = 400 - 10 \times 25 = 150$.

Check with (2): $14 \times 25 + 150 = 350 + 150 = 500$ ✓.

Therefore, a = 25 and b = 150; the relation is y = 25x + 150.

QUESTION 2

A gym charges a fixed monthly fee and an additional cost per hour for using the badminton court. A student using the gym observed that when she used the badminton court for 10 hours, her bill was ₹800. When she used it for 15 hours, her bill was ₹1100. If the monthly bill y depends on the hours of the use of the badminton court, x, according to the relation $y = ax + b$, find the values of a and b.

ANSWER

$$800 = 10a + b \quad ...(1)$$
$$1100 = 15a + b \quad ...(2)$$

Subtracting (1) from (2): $300 = 5a$, so $a = 60$. From (1): $b = 800 - 600 = 200$.

Check with (2): $15 \times 60 + 200 = 900 + 200 = 1100$ ✓.

Therefore, a = 60 and b = 200; the relation is y = 60x + 200.

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QUESTION 3

Consider the relationship between temperature measured in degrees Celsius (°C) and degrees Fahrenheit (°F), which is given by °C = *a* °F + *b*. Find *a* and *b*, given that ice melts at 0 degrees Celsius and 32 degrees Fahrenheit, and water boils at 100 degrees Celsius and 212 degrees Fahrenheit.

(**Hint:** When °C = 0, °F = 32 and when °C = 100, °F = 212. Use this information to find *a* and *b*, and thus, the linear relationship between °C and °F.)

ANSWER

$0 = 32a + b$ ...(1)
$100 = 212a + b$ ...(2)

Subtracting (1) from (2): $100 = 180a$, so $a = 100/180 = 5/9$. From (1): $b = -32 \times 5/9 = -160/9$.

$$°C = (5/9)\,°F - 160/9 = (5/9)(°F - 32)$$

Check with (2): $(5/9)(212 - 32) = (5/9) \times 180 = 100$ ✓.

Therefore, a = 5/9 and b = –160/9, so °C = (5/9)(°F – 32).

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CLASS 9 MATHS · GANITA MANJARI · CHAPTER 2

Exercise Set 2.6

2.6

Solutions · 1 question

QUESTION 1

Draw the graphs of the following sets of lines. In each case, reflect on the role of '*a*' and '*b*'.

(i) $y = 4x$, $y = 2x$, $y = x$

(ii) $y = -6x$, $y = -3x$, $y = -x$

(iii) $y = 5x$, $y = -5x$

(iv) $y = 3x - 1$, $y = 3x$, $y = 3x + 1$

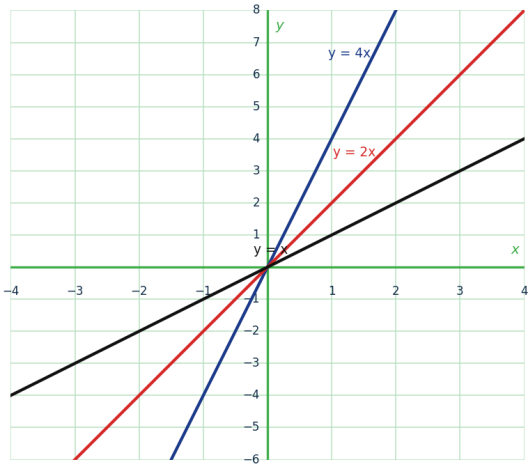
(v) $y = -2x - 3$, $y = -2x$, $y = 2x + 3$

ANSWER

For each line, take two points, plot them and join them with a ruler (extend the line on both sides).

(i) y = 4x, y = 2x, y = x

x	0	1	2
y = 4x	0	4	8
y = 2x	0	2	4
y = x	0	1	2



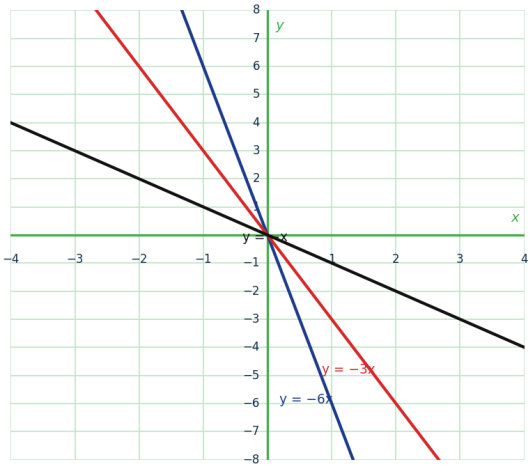
Graphs of (i)

Role of a: all three lines pass through the origin (b = 0). All have positive slope. The larger the value of *a*, the steeper the line: $y = 4x$ is the steepest and $y = x$ the least steep.

(ii) y = –6x, y = –3x, y = –x

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x	0	1	2
y = –6x	0	–6	–12
y = –3x	0	–3	–6
y = –x	0	–1	–2

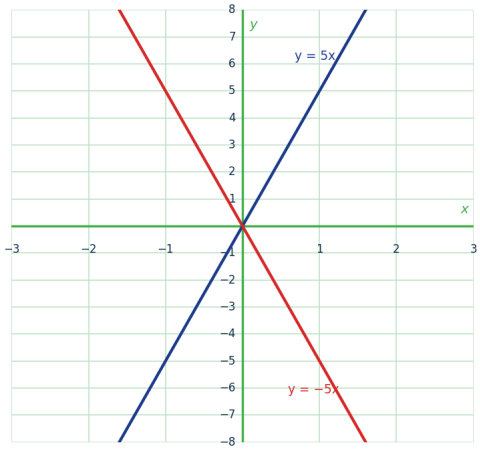


Graphs of (ii)

All pass through the origin and have negative slopes (linear decay: the lines fall from left to right). The larger the value of $|a|$, the steeper the line: $y = -6x$ is the steepest.

iii **y = 5x, y = –5x**

x	0	1	2
y = 5x	0	5	10
y = –5x	0	–5	–10



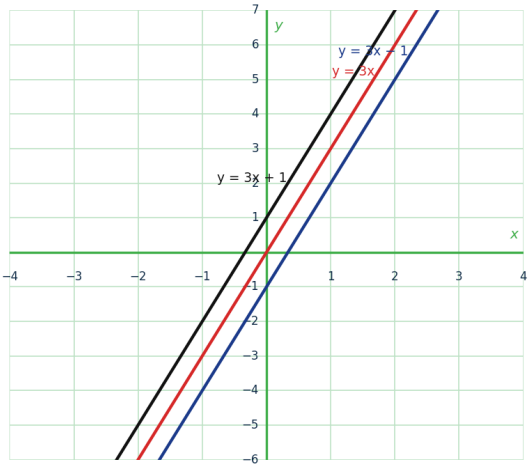
Graphs of (iii)

Both lines pass through the origin and are equally steep. The positive slope 5 gives a rising line and the negative slope –5 a falling line; they are mirror images of each other in the y-axis. So the sign of a decides whether the line rises or falls.

iv **y = 3x – 1, y = 3x, y = 3x + 1**

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x	0	1	2
y = 3x – 1	–1	2	5
y = 3x	0	3	6
y = 3x + 1	1	4	7

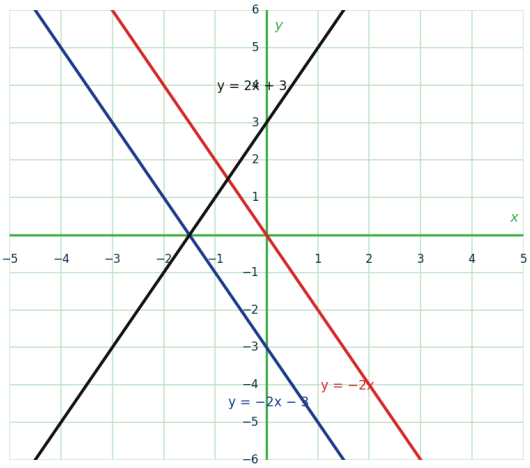


Graphs of (iv)

The slope $a = 3$ is the same, so the three lines are **parallel**. They cut the y-axis at (0, –1), (0, 0) and (0, 1): the role of b is the y-intercept; changing b shifts the line up or down.

v y = –2x – 3, y = –2x, y = 2x + 3

x	0	1	2
y = –2x – 3	–3	–5	–7
y = –2x	0	–2	–4
y = 2x + 3	3	5	7



Graphs of (v)

$y = –2x – 3$ and $y = –2x$ have equal slope –2, so they are parallel (y-intercepts –3 and 0). $y = 2x + 3$ has slope +2 (rising) and y-intercept 3; it meets $y = –2x – 3$ at (–1.5, 0) and $y = –2x$ at (–0.75, 1.5).

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Therefore, in y = ax + b the number a is the slope (steepness and direction) and b is the y-intercept (where the line cuts the y-axis).

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EOC

CLASS 9 MATHS · GANITA MANJARI · CHAPTER 2

End-of-Chapter Exercises

Solutions · 14 questions

QUESTION 1

Write a polynomial of degree 3 in the variable x, in which the coefficient of the x^2 term is –7.

ANSWER

A cubic polynomial has highest power 3. Include the term $-7x^2$. For example:

$$x^3 - 7x^2 + 2x + 1$$

Therefore, $x^3 - 7x^2 + 2x + 1$ is one such polynomial (many other answers are possible).

QUESTION 2

Find the values of the following polynomials at the indicated values of the variables.

(i) $5x^2 - 3x + 7$ if $x = 1$

(ii) $4t^3 - t^2 + 6$ if $t = a$

ANSWER

i **x = 1**

$$5 \times 1^2 - 3 \times 1 + 7 = 5 - 3 + 7 = 9$$

ii **t = a**

$$4a^3 - a^2 + 6$$

Therefore, the values are 9 and $4a^3 - a^2 + 6$.

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QUESTION 3

If we multiply a number by 5/2 and add 2/3 to the product, we get –7/12. Find the number.

ANSWER

Let the number be x.

$$(5/2)x + 2/3 = -7/12$$
$$(5/2)x = -7/12 - 2/3 = -7/12 - 8/12 = -15/12 = -5/4$$
$$x = (-5/4) \times (2/5) = -1/2$$

Check: $(5/2) \times (-1/2) + 2/3 = -5/4 + 2/3 = -15/12 + 8/12 = -7/12$ ✓.

Therefore, the number is –1/2.

QUESTION 4

A positive number is 5 times another number. If 21 is added to both the numbers, then one of the new numbers becomes twice the other new number. What are the numbers?

ANSWER

Let the numbers be x and $5x$ ($x > 0$). After adding 21: $x + 21$ and $5x + 21$. The larger new number is $5x + 21$, which is twice the smaller:

$$5x + 21 = 2(x + 21)$$
$$5x + 21 = 2x + 42$$
$$3x = 21,\ x = 7$$

The numbers are 7 and 35. Check: $7 + 21 = 28$ and $35 + 21 = 56 = 2 \times 28$ ✓. (The other possibility $x + 21 = 2(5x + 21)$ gives $x = -7/3$, which is not positive.)

Therefore, the numbers are 7 and 35.

QUESTION 5

If you have ₹800 and you save ₹250 every month, find the amount you have after (i) 6 months (ii) 2 years. Express this as a linear pattern.

ANSWER

After n months the amount is $800 + 250n$ (in ₹).

i **After 6 months**

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$$800 + 250 \times 6 = 800 + 1500 = ₹2300$$

ii **After 2 years = 24 months**

$$800 + 250 \times 24 = 800 + 6000 = ₹6800$$

Linear pattern: 1050, 1300, 1550, ... (a constant difference of 250 each month): amount = 800 + 250*n*.

Therefore, the amounts are ₹2300 and ₹6800; the linear pattern is 800 + 250n.

QUESTION 6 *

The digits of a two-digit number differ by 3. If the digits are interchanged, and the resulting number is added to the original number, we get 143. Find both the numbers.

ANSWER

Let the tens digit be *a* and the units digit be *b*. The number is 10*a* + *b* and the number with interchanged digits is 10*b* + *a*.

$$(10a + b) + (10b + a) = 143$$
$$11a + 11b = 143$$
$$a + b = 13$$

The digits differ by 3: $a - b = 3$ or $b - a = 3$.

$$a + b = 13 \text{ and } a - b = 3 \Rightarrow a = 8, b = 5 \text{ (number 85)}$$
$$a + b = 13 \text{ and } b - a = 3 \Rightarrow a = 5, b = 8 \text{ (number 58)}$$

Check: 85 + 58 = 143 ✓ and 8 – 5 = 3 ✓.

Therefore, the two numbers are 85 and 58 (each is the interchanged form of the other).

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QUESTION 7 *

Draw the graph of the following equations, and identify their slopes and *y*-intercepts. Also, find the coordinates of the points where these lines cut the *y*-axis.

(i) $y = -3x + 4$

(ii) $2y = 4x + 7$

(iii) $5y = 6x - 10$

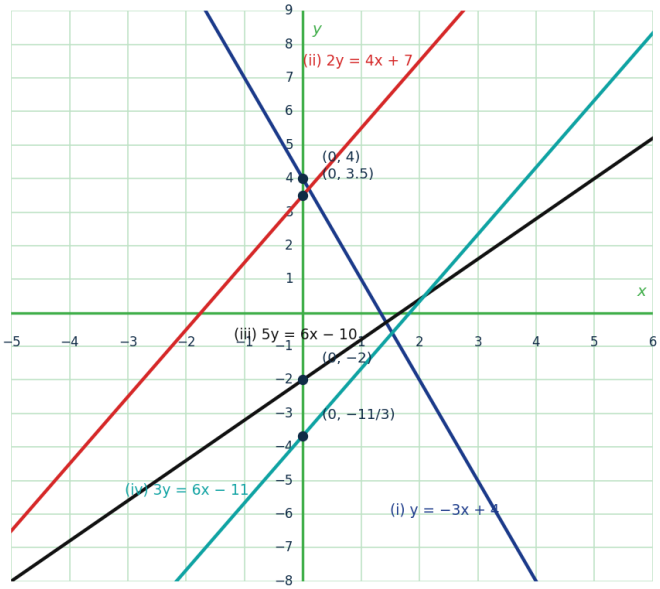
(iv) $3y = 6x - 11$

Are any of the lines parallel?

ANSWER

Write each equation in the form $y = ax + b$: a is the slope and b the y-intercept; the line cuts the y-axis at $(0, b)$.

Equation	y = ax + b	Slope a	y-intercept b	Cuts y-axis at
(i)	y = –3x + 4	–3	4	(0, 4)
(ii)	y = 2x + 7/2	2	7/2	(0, 3.5)
(iii)	y = (6/5)x – 2	6/5	–2	(0, –2)
(iv)	y = 2x – 11/3	2	–11/3	(0, –11/3)



Graphs of the four lines

Two points for each line (to plot): (i) (0, 4) and (1, 1); (ii) (0, 3.5) and (1, 5.5); (iii) (0, –2) and (5, 4); (iv) (0, –11/3) and (3, 7/3).

Therefore, lines (ii) and (iv) are parallel (both have slope 2); no other pair has equal slopes.

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QUESTION 8 *

If the temperature of a liquid can be measured in Kelvin units as x K and in Fahrenheit units as y °F, the relation between the two systems of measurement of temperature is given by the linear equation $y = (9/5)(x - 273) + 32$.

(i) Find the temperature of the liquid in Fahrenheit if the temperature of the liquid is 313 K.

(ii) If the temperature is 158 °F, then find the temperature in Kelvin.

ANSWER

i **x = 313**

$$y = (9/5)(313 - 273) + 32 = (9/5) \times 40 + 32 = 72 + 32 = 104$$

ii **y = 158**

$$158 = (9/5)(x - 273) + 32$$
$$126 = (9/5)(x - 273)$$
$$x - 273 = 126 \times 5/9 = 70$$
$$x = 343$$

Therefore, 313 K = 104 °F and 158 °F = 343 K.

QUESTION 9 *

The work done by a body on the application of a constant force is the product of the constant force and the distance travelled by the body in the direction of the force. Express this in the form of a linear equation in two variables (work w and distance d), and draw its graph by taking the constant force as 3 units. What is the work done when the distance travelled is 2 units? Verify it by plotting it on the graph.

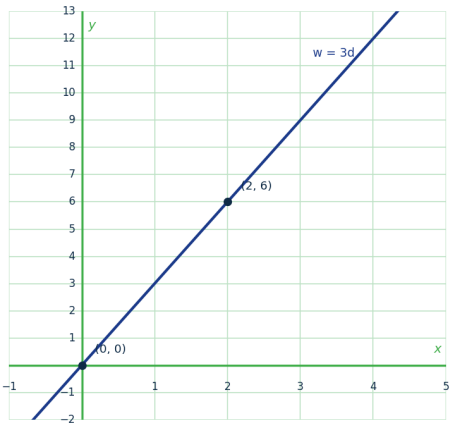
ANSWER

Work = force × distance. With force 3 units: $\boldsymbol{w = 3d}$, a linear equation through the origin (slope 3, y-intercept 0).

d	0	1	2	3
w = 3d	0	3	6	9

When $d = 2$: $w = 3 \times 2 = 6$ units. On the graph, the point with $d = 2$ on the line has w-coordinate 6, i.e. the point (2, 6) lies on the line.

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Graph of w = 3d (d on the horizontal axis, w on the vertical axis)

Therefore, w = 3d, and the work done for a distance of 2 units is 6 units.

QUESTION 10 *

The graph of a linear polynomial $p(x)$ passes through the points (1, 5) and (3, 11).

(i) Find the polynomial $p(x)$.

(ii) Find the coordinates where the graph of $p(x)$ cuts the axes.

(iii) Draw the graph of $p(x)$ and verify your answers.

ANSWER

i The polynomial

Let $p(x) = ax + b$.

5 = a + b ...(1)
11 = 3a + b ...(2)
(2) – (1): 6 = 2a, a = 3, b = 5 – 3 = 2

p(x) = 3x + 2

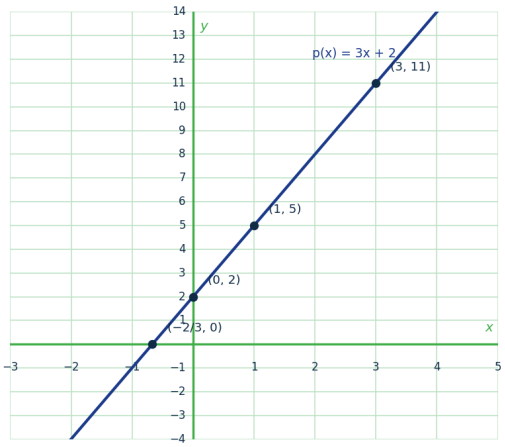
ii Where it cuts the axes

y-axis: put $x = 0$: $p(0) = 2$, so the point is (0, 2). **x-axis:** put $p(x) = 0$: $3x + 2 = 0$, $x = -2/3$, so the point is (–2/3, 0).

iii Graph

Plot (1, 5), (3, 11), (0, 2) and (–2/3, 0); they lie on one straight line, which verifies the answers.

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Graph of p(x) = 3x + 2

Therefore, p(x) = 3x + 2; it cuts the y-axis at (0, 2) and the x-axis at (–2/3, 0).

QUESTION 11 *

Let $p(x) = ax + b$ and $q(x) = cx + d$ be two linear polynomials such that:

(i) $p(0) = 5$.

(ii) The polynomial $p(x) - q(x)$ cuts the x-axis at (3, 0).

(iii) The sum $p(x) + q(x)$ is equal to $6x + 4$ for all real x.

Find the polynomials $p(x)$ and $q(x)$.

ANSWER

(i) $p(0) = b = 5$.

(iii) $p(x) + q(x) = (a + c)x + (b + d) = 6x + 4$ for all x, so $a + c = 6$ and $b + d = 4$. Hence $d = 4 - 5 = -1$.

(ii) $p(x) - q(x) = (a - c)x + (b - d) = (a - c)x + 6$. It is 0 at $x = 3$: $3(a - c) + 6 = 0$, so $a - c = -2$.

$$a + c = 6 \text{ and } a - c = -2 \Rightarrow a = 2,\ c = 4$$

Check: $p + q = (2 + 4)x + (5 - 1) = 6x + 4$ ✓; $p - q = -2x + 6 = 0$ at $x = 3$ ✓.

Therefore, p(x) = 2x + 5 and q(x) = 4x – 1.

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QUESTION 12 *

Look at the first three stages of a growing pattern of hexagons made using matchsticks. A new hexagon gets added at every stage which shares a side with the last hexagon of the previous stage.

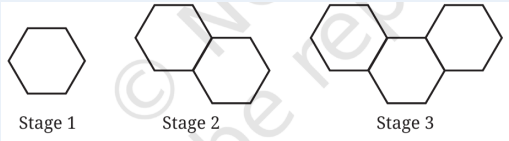
(i) Draw the next two stages of the pattern. How many matchsticks will be required at these stages?

(ii) Complete the following table.

(iii) Find a rule to determine the number of matchsticks required for the *n*th stage.

(iv) How many matchsticks will be required for the 15th stage of the pattern?

(v) Can 200 matchsticks form a stage in this pattern? Justify your answer.

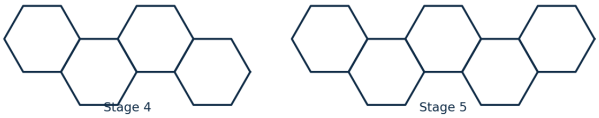


Stages 1 to 3

ANSWER

i Next two stages

Stage 1 is one hexagon: 6 matchsticks. Every new hexagon shares one side with the last hexagon, so it needs only 5 new matchsticks. Stage 2: 6 + 5 = 11; Stage 3: 11 + 5 = 16. Stage 4: 16 + 5 = **21** matchsticks; Stage 5: 21 + 5 = **26** matchsticks.



Stages 4 and 5 (redrawn)

ii Table

Stage Number	1	2	3	4	5	...	n
Number of matchsticks	6	11	16	21	26	...	5n + 1

iii Rule

The first hexagon needs 6 matchsticks and each of the other (n – 1) hexagons needs 5: 6 + 5(n – 1) = 5n + 1.

iv 15th stage

$5 \times 15 + 1 = 76$ matchsticks

v Can 200 matchsticks form a stage?

NO

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We would need $5n + 1 = 200$, i.e. $5n = 199$, $n = 39.8$, which is not a whole number. Also, 200 – 1 = 199 is not a multiple of 5 (the numbers of matchsticks are 6, 11, 16, … all of the form $5n + 1$, ending in 1 or 6).

Therefore, 21 and 26 matchsticks for Stages 4 and 5; the rule is 5n + 1; Stage 15 needs 76 matchsticks; 200 matchsticks cannot form a stage.

QUESTION 13 *

Let $p(x) = ax + b$ and $q(x) = cx + d$ be two linear polynomials such that:

(i) The graph of $p(x)$ passes through the points (2, 3) and (6, 11).

(ii) The graph of $q(x)$ passes through the point (4, –1).

(iii) The graph of $q(x)$ is parallel to the graph of $p(x)$.

Find the polynomials $p(x)$ and $q(x)$. Also, find the coordinates of the point where these lines meet the x-axis.

ANSWER

p Polynomial p(x)

$3 = 2a + b$ …(1)
$11 = 6a + b$ …(2)
(2) – (1): $8 = 4a$, $a = 2$, $b = 3 – 4 = –1$

$p(x) = 2x – 1$

q Polynomial q(x)

Parallel lines have equal slopes, so $c = 2$. Since (4, –1) lies on the graph of q: $–1 = 2 \times 4 + d$, so $d = –9$.

$q(x) = 2x – 9$

x Meeting the x-axis

$p(x) = 0$: $2x – 1 = 0$, $x = 1/2$, so the point is (1/2, 0). $q(x) = 0$: $2x – 9 = 0$, $x = 9/2$, so the point is (9/2, 0). (The two lines are parallel, so they do not meet each other; each meets the x-axis at its own point.)

Therefore, p(x) = 2x – 1 and q(x) = 2x – 9; they meet the x-axis at (1/2, 0) and (9/2, 0).

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QUESTION 14 *

What do all linear functions of the form $f(x) = ax + a$, $a > 0$, have in common?

ANSWER

$f(x) = ax + a = a(x + 1)$. At $x = -1$: $f(-1) = a(-1 + 1) = 0$, whatever the value of a.

So every such line passes through the point (–1, 0) on the x-axis (their x-intercept is –1). They differ only in slope a, which is positive, so all of them are rising lines (linear growth).

Therefore, all the graphs pass through the common point (–1, 0) and have positive slope.

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