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Elite Mathematics
Pearson Edexcel International GCSE

IGCSE LINEAR · 4MA1

4MA1/1H November 2023 Worked Solutions

November 2023 paper rebuilt with the worked solution after each question.

24	2020–2026	Single-paper solutions
paper questions	52 past papers	checked by Dr Eslam



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PAST PAPER

4MA1/1H November 2023

November 2023

24	100	2 h
questions	marks	exam time

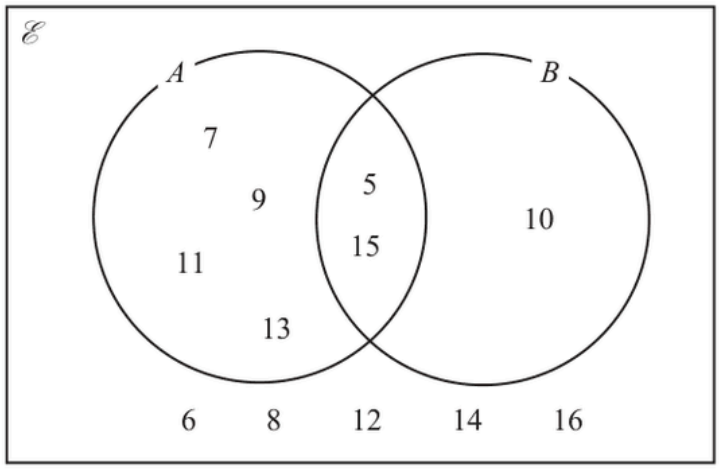
Each question is followed by its worked solution and final answer.

4MA1/1H NOVEMBER 2023

Question 1

3 marks | Set Notation & Venn Diagrams

1 Here is a Venn diagram.



List the members of the set

(a) A

.....

(1)

(b) $A \cap B$

.....

(1)

(c) $(A \cup B)'$

.....

(1)

(Total for Question 1 is 3 marks)

WORKED SOLUTION

Question 1 · 4MA1/1H November 2023

1 **The members of are all**

The members of A are all the numbers inside circle A, including the overlap:

$$A = \{5, 7, 9, 11, 13, 15\}$$

2 **The members of are the**

The members of $A \cap B$ are the numbers in both circles:

$$A \cap B = \{5, 15\}$$

3 **means outside both circles**

$(A \cup B)'$ means outside both circles:

$$(A \cup B)' = \{6, 8, 12, 14, 16\}$$

✓ **FINAL ANSWER**

(a) $\{5, 7, 9, 11, 13, 15\}$, (b) $\{5, 15\}$, (c) $\{6, 8, 12, 14, 16\}$

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Question 2

6 marks | Forming & Solving Equations

2 (a) Factorise fully $12pq - 18p$

.....

(2)

There are 56 metal bars in a box.
Each metal bar is gold or silver or zinc.

y metal bars are gold.
$(3y + 7)$ metal bars are silver.
$(2y - 5)$ metal bars are zinc.

(b) Work out the number of metal bars that are zinc.
Show clear algebraic working.

.....

(4)

(Total for Question 2 is 6 marks)

WORKED SOLUTION

Question 2 · 4MA1/1H November 2023

1 **(a)**

(a)

$$12pq - 18p = 6p(2q - 3)$$

2 **Solve equation**

(b) The total number of bars is 56, so

$$y + (3y + 7) + (2y - 5) = 56$$

$$6y + 2 = 56$$

$$y = 9$$

3 **The number of zinc bars**

The number of zinc bars is

$$2y - 5 = 2(9) - 5 = 13$$

FINAL ANSWER

(a) $6p(2q - 3)$, (b) 13 zinc bars

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Question 3

4 marks | Reverse Percentages

3 Joshua buys a car for $12 500

He sells the car to Nina.

Nina pays

- a deposit of $1500
- followed by 36 monthly payments of $450

Work out Joshua's percentage profit.

.....%

(Total for Question 3 is 4 marks)

WORKED SOLUTION

Question 3 · 4MA1/1H November 2023

1 Nina pays

Nina pays

$$1500 + 36(450) = 1500 + 16200 = 17700$$

2 Joshua s profit is

Joshua's profit is

$$17700 - 12500 = 5200$$

3 Percentage profit

Percentage profit:

$$\frac{5200}{12500} \times 100 = 41.6$$

FINAL ANSWER

41.6%

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Question 4

4 marks | Probability Toolkit

4 A biased spinner has three sections each of a different colour.

The table shows the probability that, when the spinner is spun once, it will land on blue or on orange or on white.

Colour	blue	orange	white
Probability	0.58	$2x$	x

(a) Work out the value of x

$x =$ .....

(2)

The spinner is spun 250 times.

(b) Work out an estimate for the number of times the spinner will land on blue.

.....

(2)

(Total for Question 4 is 4 marks)

WORKED SOLUTION

Question 4 · 4MA1/1H November 2023

1 **(a) Probabilities add to 1**

$$0.58 + 2x + x = 1 \Rightarrow 3x = 0.42 \Rightarrow x = 0.14$$

2 **(b) Estimate for blue in 250 spins**

$$250 \times 0.58 = 145$$

✓ **FINAL ANSWER**

(a) $x = 0.14$ (b) 145

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Question 5

3 marks | Circles, Arcs & Sectors

5 The diagram shows a shaded shape made from three identical semicircles, X, Y and Z

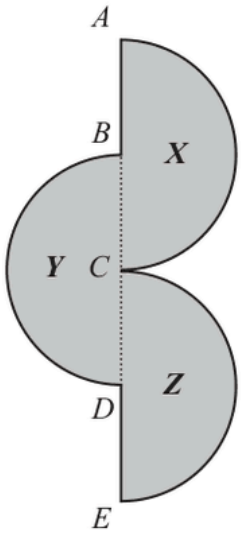


Diagram **NOT** accurately drawn

$ABCDE$ is a straight line.

AC is the diameter of semicircle X and B is the centre of semicircle X
BD is the diameter of semicircle Y and C is the centre of semicircle Y
CE is the diameter of semicircle Z and D is the centre of semicircle Z

$AC = BD = CE = 20$ cm

Work out the perimeter of the shaded shape.
Give your answer correct to the nearest whole number.

..... cm

(Total for Question 5 is 3 marks)

WORKED SOLUTION

Question 5 · 4MA1/1H November 2023

1 Each semicircle has diameter

Each semicircle has diameter 20 cm, so each has radius 10 cm.

2 The total curved perimeter is

The total curved perimeter is three semicircles:

$$3 \times \pi r = 3 \times 10\pi = 30\pi$$

3 The two exposed straight parts

The two exposed straight parts are

$$AB = 10, \qquad DE = 10$$

4 Calculate value

So the perimeter is

$$30\pi + 20 = 114.2\ldots$$

FINAL ANSWER

$114\ \text{cm}$ to the nearest whole number.

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Question 6

4 marks | Reverse Percentages

6 Juan wants to buy a ticket to fly from Madrid to Berlin.

He finds two different types of ticket he can buy in a sale, ticket **A** and ticket **B**

ticket **A**	ticket **B**
$\frac{1}{6}$ off normal price	20% off normal price

The sale price of ticket **A** is 140 euros.
The sale price of ticket **B** is 136 euros.

Work out the difference between the normal price of ticket **A** and the normal price of ticket **B**

..... euros

(Total for Question 6 is 4 marks)

WORKED SOLUTION

Question 6 · 4MA1/1H November 2023

1 Calculate percentage

Ticket A is sold for $\frac{5}{6}$ of its normal price.

$$\text{normal price of A} = 140 \times \frac{6}{5} = 168$$

2 Calculate percentage

Ticket B has a 20% discount, so its sale price is 80% of the normal price.

$$\text{normal price of B} = 136 \div 0.80 = 170$$

3 The difference is

The difference is

$$170 - 168 = 2$$

FINAL ANSWER

The difference in normal prices is 2 euros.

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Question 7

2 marks | Prime Factors, HCF & LCM

7 $A = 5^3 \times 7^3 \times 11^6$ and $B = 5^6 \times 7^2 \times 11^4$

Find the highest common factor (HCF) of A and B
Give your answer as a product of powers of its prime factors.

(Total for Question 7 is 2 marks)

WORKED SOLUTION

Question 7 · 4MA1/1H November 2023

1 Find the LCM

$$A = 5^3 \times 7^3 \times 11^6$$

$$B = 5^6 \times 7^2 \times 11^4$$

2 The HCF takes the smaller

The HCF takes the smaller power of each common prime:

$$\text{HCF} = 5^3 \times 7^2 \times 11^4$$

FINAL ANSWER

$5^3 \times 7^2 \times 11^4$

Question 8

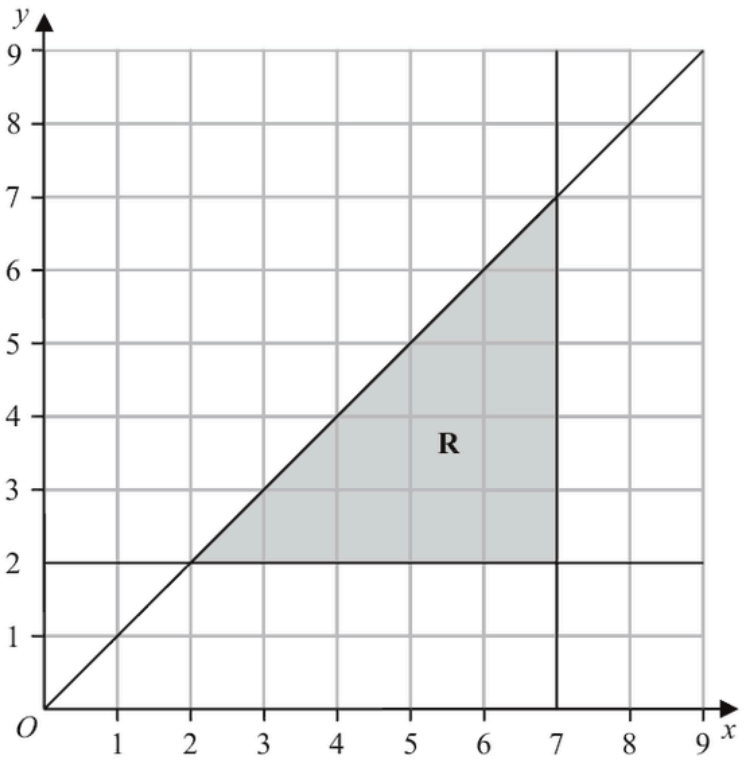
5 marks | Inequalities (Solving & Graphing)

8 (a) Solve the inequality $8x - 4 \geqslant 3x - 10$

.....

(2)

The region **R**, shown shaded in the diagram, is bounded by three straight lines.



(b) Write down the three inequalities that define the region **R**

.....

(3)

(Total for Question 8 is 5 marks)

1 Evaluate fraction

For part (a),

$$8x - 4 \geq 3x - 10$$

$$5x \geq -6$$

$$x \geq -\frac{6}{5}$$

2 Solve inequality

For part (b), the region is above $y = 2$, left of $x = 7$, and below $y = x$:

$$y \geq 2$$

$$x \leq 7$$

$$y \leq x$$

FINAL ANSWER

(a) $x \geq -\frac{6}{5}$. (b) $y \geq 2$, $x \leq 7$, $y \leq x$.

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Question 9

4 marks | Standard Form

9 (a) Write 5.87×10^{-4} as an ordinary number.

.....

(1)

(b) Write 84 000 000 in standard form.

.....

(1)

The number of neurons in a human brain is 8.5×10^{10}
The number of neurons in a monkey brain is 1.47×10^{9}

The number of neurons in a human brain is K × the number of neurons in a monkey brain.

(c) Work out the value of K
Give your answer correct to one decimal place.

$K =$ .....

(2)

(Total for Question 9 is 4 marks)

WORKED SOLUTION

Question 9 · 4MA1/1H November 2023

1 Convert standard form

$$5.87 \times 10^{-4} = 0.000587$$

$$84000000 = 8.4 \times 10^{7}$$

2 Convert standard form

For part (c),

$$K = \frac{8.5 \times 10^{10}}{1.47 \times 10^{9}}$$

$$K = \frac{8.5}{1.47} \times 10$$

$$K = 57.823\ldots$$

3 **Convert standard form**

Correct to one decimal place,

$$K = 57.8$$

✓ **FINAL ANSWER**

(a) 0.000587, (b) 8.4×10^{7}, (c) 57.8

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Question 10

5 marks | Right-Angled Triangles - Pythagoras & Trigonometry

10 Here is triangle ABC

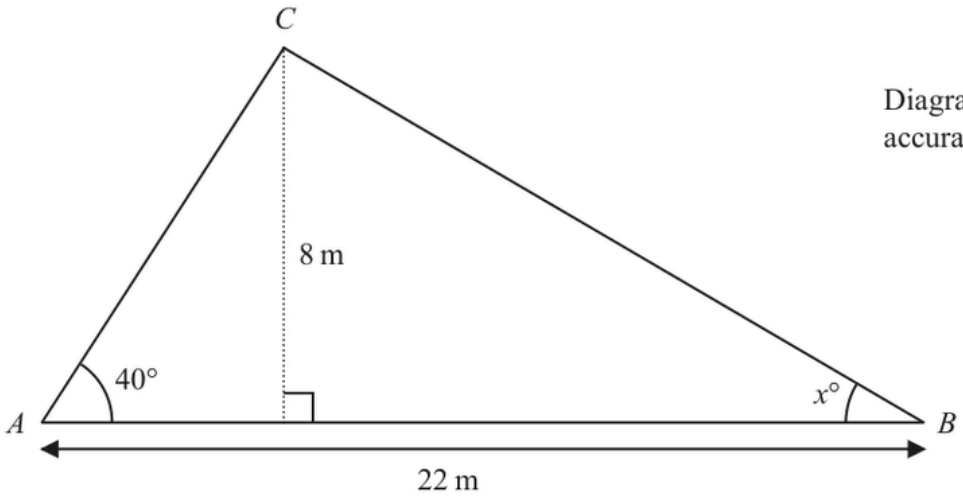


Diagram **NOT** accurately drawn

Work out the value of x
Give your answer correct to one decimal place.
Show your working clearly.

$x =$ .....

(Total for Question 10 is 5 marks)

WORKED SOLUTION

Question 10 · 4MA1/1H November 2023

1 **Let the perpendicular from meet**

Let the perpendicular from C meet AB at F.

$$AF = \frac{8}{\tan 40^\circ} = 9.534\ldots$$

$$FB = 22 - 9.534\ldots = 12.465\ldots$$

2 **Use trigonometry**

In right-angled triangle CFB,

$$\tan x = \frac{8}{12.465\ldots}$$

$$x = 32.7^\circ$$

FINAL ANSWER

$32.7°$.

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Question 11

3 marks | Algebraic Fractions

11 Express $\frac{3}{4}+\frac{5-x}{6x}$ as a single fraction in its simplest terms.

(Total for Question 11 is 3 marks)

WORKED SOLUTION

Question 11 · 4MA1/1H November 2023

1 Simplify fraction

$$\frac{3}{4}+\frac{5-x}{6x}$$

2 The common denominator is

The common denominator is $12x$:

$$\frac{3}{4}=\frac{9x}{12x}$$

$$\frac{5-x}{6x}=\frac{10-2x}{12x}$$

$$\frac{9x+10-2x}{12x}=\frac{7x+10}{12x}$$

FINAL ANSWER

$\frac{7x+10}{12x}$.

Question 12

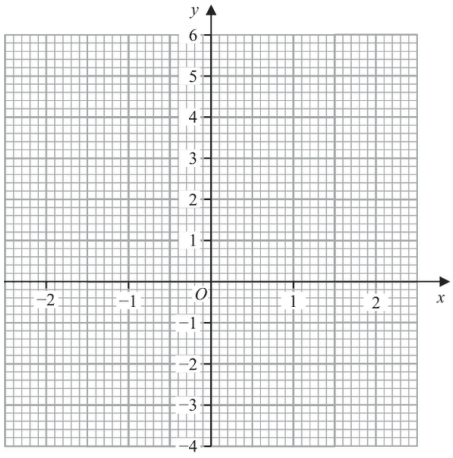
5 marks | Graphs of Functions

12 (a) Complete the table of values for $y = x^3 - 3x + 1$

x	−2	−1	0	1	2
y				−1	

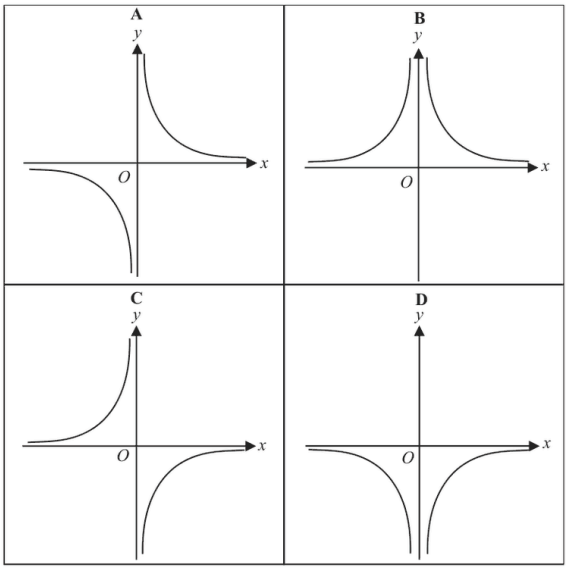
(2)

(b) On the grid, draw the graph of $y = x^3 - 3x + 1$ for values of x from − 2 to 2



(2)

Here are four graphs.



(c) Write down the letter of the graph that could have the equation $y = -\frac{1}{x^2}$

(1)

(Total for Question 12 is 5 marks)

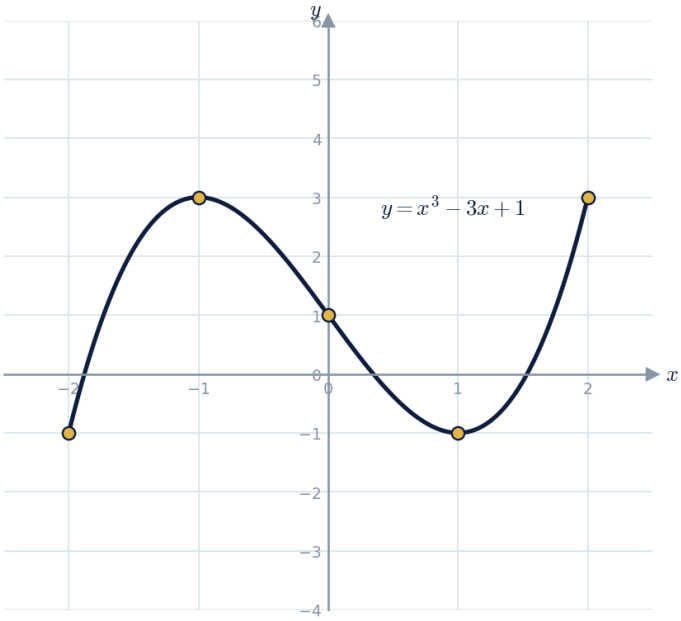
1 Read the graph

$$y = x^3 - 3x + 1$$

2 The completed table is

The completed table is:

x	-2	-1	0	1	2
y	-1	3	1	-1	3



3 The graph of is below

The graph of

$$y = -\frac{1}{x^2}$$

is below the x-axis on both sides and is symmetrical in the y-axis.

FINAL ANSWER

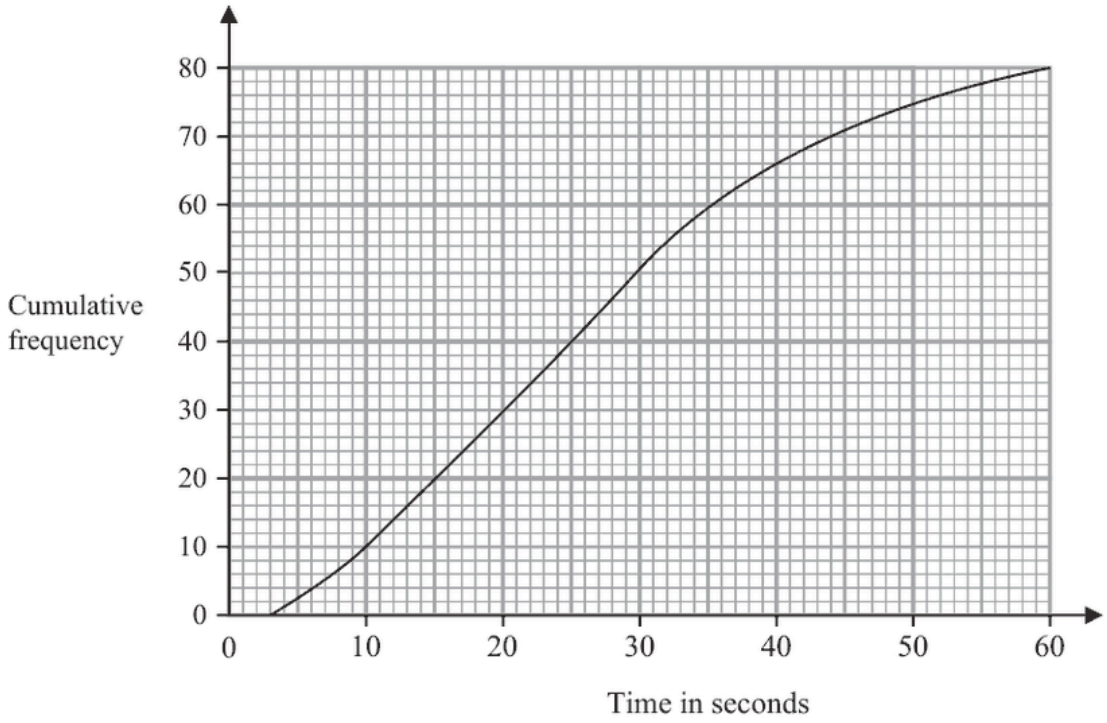
The graph letter is D.

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Question 13

4 marks | Cumulative Frequency Diagrams

13 The cumulative frequency graph gives information about the times, in seconds, that 80 adults took to log in to an online bank.



(a) Find an estimate for the median time.

..... seconds

(1)

(b) Work out the percentage of these adults that took longer than 50 seconds to log in.
Show your working clearly.

.....%

(3)

(Total for Question 13 is 4 marks)

WORKED SOLUTION

Question 13 · 4MA1/1H November 2023

1 **(a) Median**

Read across from $\frac{80}{2} = 40$: about 25 seconds.

2 **(b) Adults who took longer than 50 seconds**

At 50 seconds the curve reads about 75, so $80 - 75 = 5$ adults.

3 (b) Percentage

$$\frac{5}{80} \times 100 = 6.25\%$$

FINAL ANSWER

(a) about 25 seconds (b) about 6.25%

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Question 14

3 marks | Circle Theorems

14

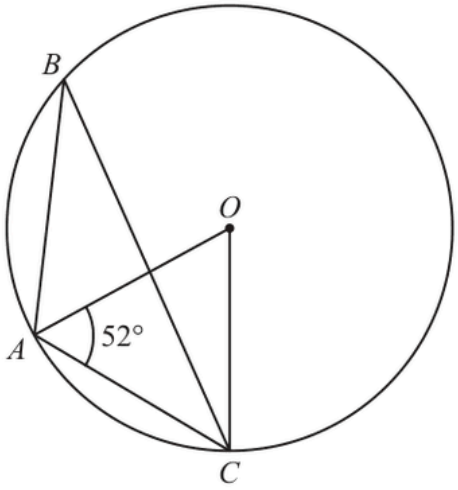


Diagram **NOT** accurately drawn

A, B and C are points on a circle, centre O

Angle $OAC = 52°$

Find the size of angle ABC
Give reasons for your working.

.....°

(Total for Question 14 is 3 marks)

WORKED SOLUTION

Question 14 · 4MA1/1H November 2023

1 Use trigonometry

Since $OA = OC$, triangle AOC is isosceles.

$$\angle ACO = \angle OAC = 52°$$

2 Use trigonometry

So

$$\angle AOC = 180° - 52° - 52° = 76°$$

3 The angle at the circumference

The angle at the circumference is half the angle at the centre standing on the same arc:

$$\angle ABC = \frac{76°}{2} = 38°$$

FINAL ANSWER

$38°$.

4MA1/1H NOVEMBER 2023

Question 15

3 marks | Rearranging Formulae

15 Make n the subject of the formula $x = \dfrac{3p+n}{3n-4}$

(Total for Question 15 is 3 marks)

WORKED SOLUTION

Question 15 · 4MA1/1H November 2023

1 Rearrange formula

$$x = \frac{3p+n}{3n-4}$$

$$x(3n-4) = 3p+n$$

$$3xn - 4x = 3p+n$$

$$n(3x-1) = 3p+4x$$

FINAL ANSWER

$n = \frac{3p+4x}{3x-1}$

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Question 16

4 marks | Differentiation & Turning Points

16 A curve has equation $y = 4x^3 - 8x + 5$

Find the x coordinates of the two points on the curve where the gradient is $\frac{1}{3}$

(Total for Question 16 is 4 marks)

WORKED SOLUTION

Question 16 · 4MA1/1H November 2023

1 **Find the gradient**

$$y = 4x^3 - 8x + 5$$

$$\frac{dy}{dx} = 12x^2 - 8$$

2 **Find the gradient**

The gradient is $\frac{1}{3}$, so

$$12x^2 - 8 = \frac{1}{3}$$

$$12x^2 = \frac{25}{3}$$

$$x^2 = \frac{25}{36}$$

$$x = \frac{5}{6} \quad \text{or} \quad x = -\frac{5}{6}$$

FINAL ANSWER

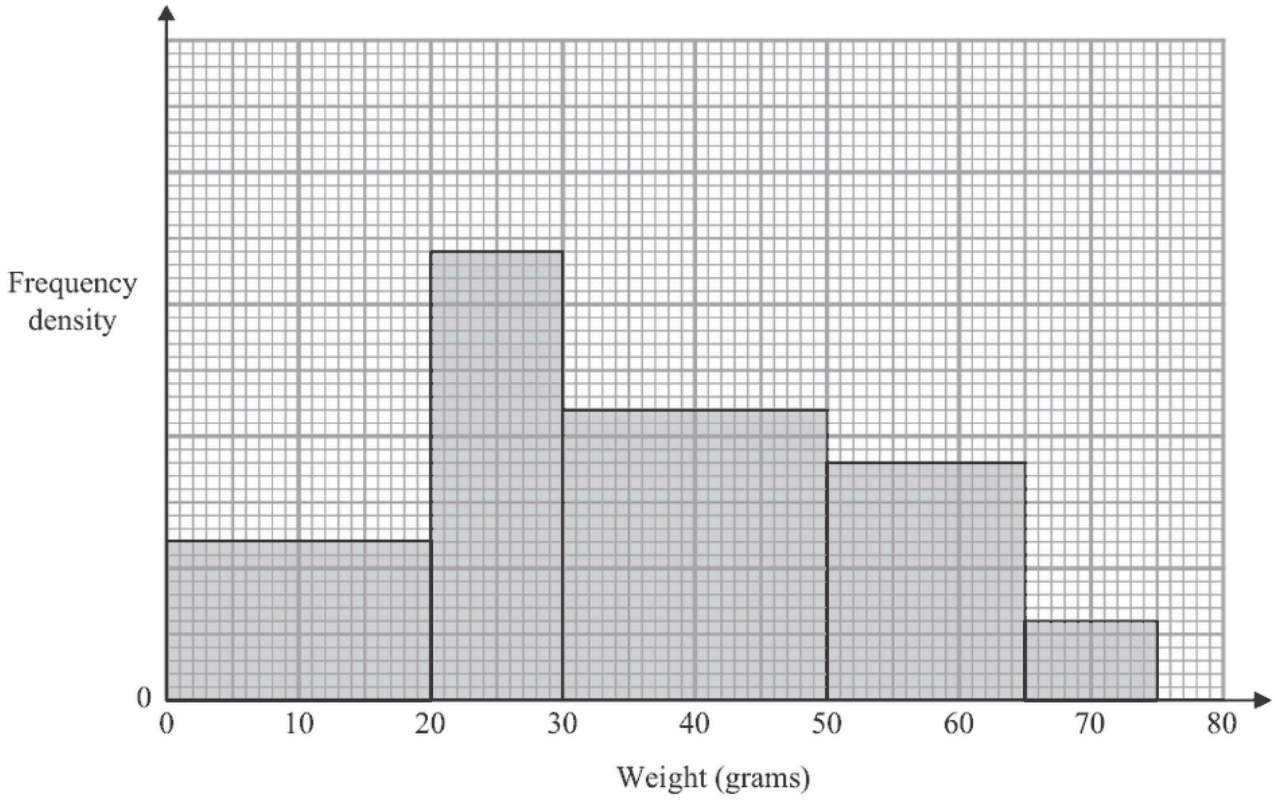
$x = \frac{5}{6}$ or $x = -\frac{5}{6}$.

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Question 17

3 marks | Histograms

17 The histogram gives information about the weights, in grams, of some oranges in a box.



24 of these oranges weigh less than 20 grams.

Medium oranges weigh between 35 grams and 55 grams.

Work out an estimate for the number of medium oranges in the box.

(Total for Question 17 is 3 marks)

WORKED SOLUTION

Question 17 · 4MA1/1H November 2023

1 **The to gram class has**

The 0 to 20 gram class has frequency 24, so its density is

$$\frac{24}{20} = 1.2$$

2 **Use histogram**

From the histogram scale, the density for $30 < w \leq 50$ is about 2.2, and the density for $50 < w \leq 65$ is about 1.8.

3 **Medium oranges weigh between g**

Medium oranges weigh between 35 g and 55 g:

$$15(2.2) + 5(1.8) = 33 + 9 = 42$$

✓ **FINAL ANSWER**

about 42 medium oranges.

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Question 18

5 marks | Bearings

18 The diagram shows the positions of three villages, A, B and C

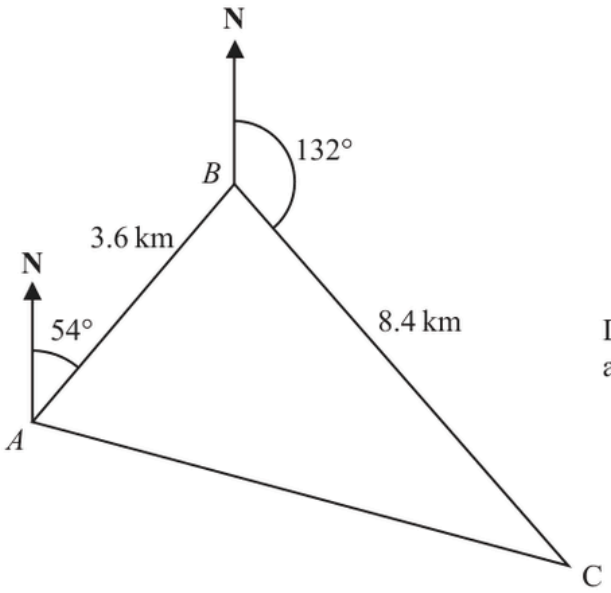


Diagram **NOT** accurately drawn

The bearing of B from A is 054°
The bearing of C from B is 132°

Melur walks from A to B
She then walks from B to C and from C to A

Melur walks at an average speed of 6 km/h

Work out the total time Melur takes.
Give your answer in hours and minutes.

..... hours ..... minutes

(Total for Question 18 is 5 marks)

WORKED SOLUTION

Question 18 · 4MA1/1H November 2023

1 **The bearing of from is**

The bearing of B from A is $054°$, so the bearing of A from B is

$$054° + 180° = 234°$$

2 **The bearing of from is**

The bearing of C from B is $132°$.

3 **Use bearings**

So

$$\angle ABC = 234° - 132° = 102°$$

4 **Use cosine rule**

Use the cosine rule to find AC:

$$AC^2 = 3.6^2 + 8.4^2 - 2(3.6)(8.4)\cos 102°$$

$$AC = 9.8028\ldots \text{ km}$$

5 **Total distance walked**

Total distance walked:

$$3.6 + 8.4 + 9.8028\ldots = 21.8028\ldots \text{ km}$$

6 **Use bearings**

At 6 km/h, time is

$$21.8028\ldots \div 6 = 3.6338\ldots \text{ hours}$$

$$0.6338\ldots \times 60 = 38.0\ldots \text{ minutes}$$

✓ **FINAL ANSWER**

3 hours 38 minutes.

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Question 19

6 marks | Sequences

19 Here are the first 4 terms in an arithmetic sequence.

3 7 11 15

The last term of the sequence is x
The sum of the terms of the sequence is 7260

Find the value of x
Show clear algebraic working.

$x =$ .....

(Total for Question 19 is 6 marks)

WORKED SOLUTION

Question 19 · 4MA1/1H November 2023

1 The sequence is

The sequence is

$$3,\ 7,\ 11,\ 15$$

2 Find the nth term

The common difference is 4, so the nth term is

$$4n - 1$$

3 Find the nth term

The last term is x, so

$$x = 4n - 1$$

$$n = \frac{x + 1}{4}$$

4 The sum is 7260

The sum is 7260:

$$\frac{n}{2}(3 + x) = 7260$$

5 **Substitute**

Substitute $n = \dfrac{x+1}{4}$:

$$\frac{x+1}{8}(x+3) = 7260$$

$$(x+1)(x+3) = 58080$$

$$x^2 + 4x - 58077 = 0$$

---

6 **Factorise**

Factorise:

$$(x-239)(x+243) = 0$$

---

7 **Find the nth term**

The last term is positive, so

$$x = 239$$

✓ **FINAL ANSWER**

$x = 239$.

4MA1/1H NOVEMBER 2023

Question 20

4 marks | Probability Toolkit

20 A bag contains only 10 cent coins and 20 cent coins.

Josip takes at random a coin from the bag, records its value and replaces it in the bag. He then takes at random a second coin from the bag, records its value and replaces it in the bag.

Josip finds the mean value of the two coins.

The probability that the two coins have a mean value of 10 cents is $\frac{49}{121}$

Work out the probability that the two coins have a mean value of 15 cents.

(Total for Question 20 is 4 marks)

WORKED SOLUTION

Question 20 · 4MA1/1H November 2023

1 Let the probability of taking

Let the probability of taking a 10 cent coin be p.

2 The mean is 10 cents

The mean is 10 cents only when both coins are 10 cent coins.

$$p^2 = \frac{49}{121}$$

$$p = \frac{7}{11}$$

3 Calculate probability

So the probability of taking a 20 cent coin is

$$1 - \frac{7}{11} = \frac{4}{11}$$

4 The mean is 15 cents

The mean is 15 cents when one coin is 10 cents and the other is 20 cents.

5 **There are two possible orders**

There are two possible orders:

$$P(10, 20) + P(20, 10)$$

$$= \frac{7}{11} \cdot \frac{4}{11} + \frac{4}{11} \cdot \frac{7}{11}$$

$$= \frac{56}{121}$$

✓ **FINAL ANSWER**

$\frac{56}{121}$

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Question 21

5 marks | Volume & Surface Area

21 Here is a triangular prism $ABCDEF$

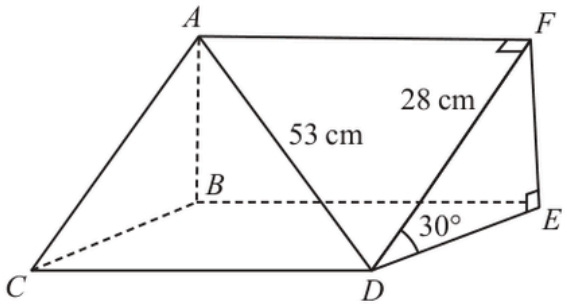


Diagram **NOT** accurately drawn

$AD = 53$ cm
$DF = 28$ cm
Angle $FDE = 30°$

Work out the volume of the triangular prism.
Give your answer correct to the nearest whole number.

..... cm^3

(Total for Question 21 is 5 marks)

WORKED SOLUTION

Question 21 · 4MA1/1H November 2023

1 The triangular cross section is

The triangular cross-section is triangle DEF.

2 It is right angled at

It is right-angled at E, with

$$DF = 28$$

3 Use trigonometry

and

$$\angle FDE = 30°$$

4 Use trigonometry

So

$$FE = 28 \sin 30° = 14$$

5 **Use trigonometry**

and

$$DE = 28\cos 30^\circ = 14\sqrt{3}$$

---

6 **Area of triangle**

Area of triangle DEF:

$$\frac{1}{2}(14)(14\sqrt{3}) = 98\sqrt{3}$$

---

7 **The length of the prism**

The length of the prism is

$$AD = 53$$

---

8 **Volume of the prism**

Volume of the prism:

$$98\sqrt{3} \times 53$$

$$= 5194\sqrt{3}$$

$$= 8996.2719\ldots$$

✓ **FINAL ANSWER**

$\boxed{8996\ \text{cm}^3}$

4MA1/1H NOVEMBER 2023

Question 22

6 marks | Linear Graphs

22 [In this question 1 cm = 1 unit on the x-axis and 1 cm = 1 unit on the y-axis]

P is a point on a circle with centre $(0, 0)$
The coordinates of P are $(8, -10)$

The line **L** is the tangent to the circle at the point P
L crosses the x-axis at the point Q and crosses the y-axis at the point R

Work out the length of RQ
Give your answer correct to 3 significant figures.

..... cm

(Total for Question 22 is 6 marks)

WORKED SOLUTION

Question 22 · 4MA1/1H November 2023

1 The centre of the circle

The centre of the circle is $(0, 0)$, and

$$P = (8, -10)$$

2 The gradient of is

The gradient of OP is

$$\frac{-10}{8} = -\frac{5}{4}$$

3 Find the gradient

So the gradient of the tangent is

$$\frac{4}{5}$$

4 The tangent through is

The tangent through P is

$$y + 10 = \frac{4}{5}(x - 8)$$

$$y = \frac{4}{5}x - \frac{82}{5}$$

5 **Evaluate fraction**

At the x-axis, $y = 0$:

$$0 = \frac{4}{5}x - \frac{82}{5}$$

$$x = \frac{41}{2}$$

---

6 **Evaluate fraction**

So

$$Q = \left(\frac{41}{2}, 0\right)$$

---

7 **Evaluate fraction**

At the y-axis, $x = 0$:

$$R = \left(0, -\frac{82}{5}\right)$$

---

8 **Simplify surd**

Therefore

$$RQ = \sqrt{\left(\frac{41}{2}\right)^2 + \left(\frac{82}{5}\right)^2}$$

$$RQ = 26.252\ldots$$

✓ **FINAL ANSWER**

$26.3\ \text{cm}$

4MA1/1H NOVEMBER 2023

Question 23

5 marks | Area & Volume of Similar Shapes

23 Solid **A** is similar to solid **B**

Here is some information about solid **A** and solid **B**

	solid **A**	solid **B**
Height (cm)	3^x	
Area (cm^2)	7776	486
Volume (cm^3)	8^x	2^{x+4}

Work out the height of solid **B**
Give your answer as a decimal.

..... cm

(Total for Question 23 is 5 marks)

WORKED SOLUTION

Question 23 · 4MA1/1H November 2023

1 **The area ratio of solid**

The area ratio of solid A to solid B is

$$7776 : 486 = 16 : 1$$

2 **Split the ratio**

So the linear ratio A:B is

$$\sqrt{16} : 1 = 4 : 1$$

3 **Split the ratio**

Therefore the volume ratio A:B is

$$4^3 : 1^3 = 64 : 1$$

4 **Calculate volume**

The volumes are 8^x and 2^{x+4}, so

$$\frac{8^x}{2^{x+4}} = 64$$

5 **Use index laws**

Write 8^x as a power of 2:

$$8^x = (2^3)^x = 2^{3x}$$

6 **Evaluate fraction**

So

$$\frac{2^{3x}}{2^{x+4}} = 2^6$$

$$2^{3x-(x+4)} = 2^6$$

$$2x - 4 = 6$$

$$x = 5$$

7 **The height of solid A**

The height of solid A is

$$3^x = 3^5 = 243$$

8 **Split the ratio**

Since the linear ratio A:B is $4 : 1$, the height of solid B is

$$\frac{243}{4} = 60.75$$

✓ **FINAL ANSWER**

$\boxed{60.75 \text{ cm}}$

Question 24

4 marks | Transformations of Graphs

24 The curve with equation $f(x) = 5x^2 + 9x + 2$ is transformed to the curve with equation

$g(x) = 5(x+4)^2 + 9(x+4) + 8$ by the translation $\begin{pmatrix} a \\ b \end{pmatrix}$

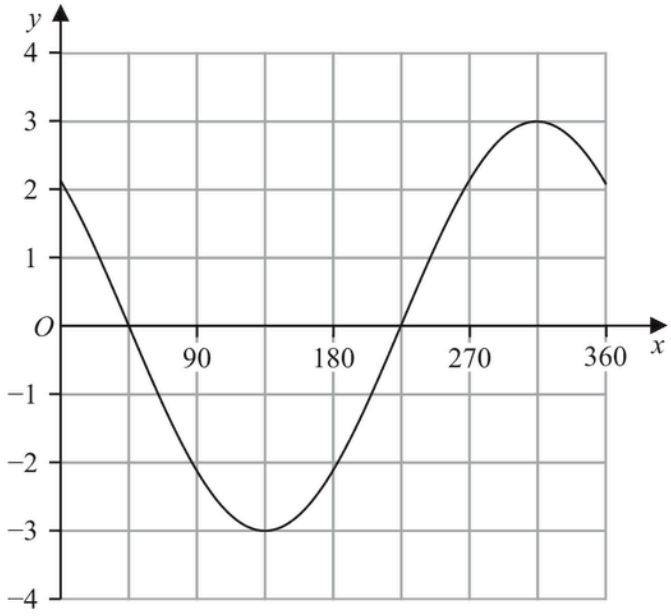
(a) Write down the value of a and the value of b

$a =$ .....

$b =$ .....

(2)

The graph of $y = p\cos(x+q)^\circ$ for $0 \leqslant x \leqslant 360$ is drawn on the grid below.



Given that $p > 0$ and $0 < q < 360$

(b) find the value of p and the value of q

$p =$ .....

$q =$ .....

(2)

(Total for Question 24 is 4 marks)

1 **Read the graph**

For part (a),

$$f(x) = 5x^2 + 9x + 2$$

$$g(x) = 5(x+4)^2 + 9(x+4) + 8$$

2 **Read the graph**

Since

$$f(x+4) = 5(x+4)^2 + 9(x+4) + 2$$

$$g(x) = f(x+4) + 6$$

3 **Read the graph**

So the graph has moved 4 units left and 6 units up.

$$\begin{pmatrix} a \\ b \end{pmatrix} = \begin{pmatrix} -4 \\ 6 \end{pmatrix}$$

4 **Read the graph**

For part (b), the graph has maximum value 3 and minimum value -3, so

$$p = 3$$

5 **The minimum occurs when**

The minimum occurs when

$$x + q = 180$$

6 **Read the graph**

From the graph, the minimum is at $x = 135$, so

$$135 + q = 180$$

$$q = 45$$

✓ **FINAL ANSWER**

$a = -4,\ b = 6,\ p = 3,\ q = 45$