

WASSCE

2026 Red Mock

CORE MATHEMATICS

Paper 1: 50 Objective Questions — ALL compulsory · 50 marks · 1 hour 30 min

Paper 2: Section A: 5 compulsory questions × 8 marks = 40 marks

Section B: 8 questions — answer any FIVE × 12 marks = 60 marks

Duration: Paper 1: 1 hour 30 min | Paper 2: 2 hours 30 min

★ **New:** **Introductory Calculus included in Paper 1 and Paper 2 Section B Q13.**

Answers: **Full model answers and marking scheme at the end of this booklet.**

Key Exam Tips — Read Before Starting

- Solve direct mathematical questions FIRST — they carry the same marks as word problems and take less time.
- Word problems: read twice, draw a diagram, THEN form equations.
- Show ALL working — method marks are awarded even if final answer is wrong.
- Ogive: ALWAYS plot cumulative frequency against UPPER CLASS BOUNDARY.
- Calculus: $dy/dx = 0$ at stationary points. Second derivative tells you max (negative) or min (positive).

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BEWARE OF EXAM SCAMMERS!

No one has WASSCE papers before the exam. Do NOT pay anyone for leaked questions.

PAPER 1 — OBJECTIVE TEST

Answer ALL 50 questions · Circle the letter of the correct answer · 50 marks · 1h 30min

1. If $5 \otimes x \equiv 3 \pmod{7}$, find the value of x .
 - A. 2
 - B. 3
 - C. 5
 - D. 6
2. Convert 110101 to base 10.
 - A. 51
 - B. 53
 - C. 55
 - D. 57
3. Simplify $\sqrt{48} - 2\sqrt{3} + \sqrt{75}$.
 - A. $5\sqrt{3}$
 - B. $7\sqrt{3}$
 - C. $9\sqrt{3}$
 - D. $11\sqrt{3}$
4. Express 0.000372 in standard form.
 - A. 3.72×10
 - B. 3.72×10^3
 - C. 37.2×10
 - D. 0.372×10^3
5. If $n(A) = 20$, $n(B) = 15$ and $n(A \cap B) = 8$, find $n(A \cup B)$.
 - A. 27
 - B. 28
 - C. 35
 - D. 43
6. A trader bought goods for GHS 450 and sold them at a 20% profit. Find the selling price.
 - A. GHS 500
 - B. GHS 520
 - C. GHS 540
 - D. GHS 560
7. Kofi deposited GHS 3,200 in a bank at 12.5% simple interest per annum. Find the interest after 2 years.
 - A. GHS 400
 - B. GHS 600
 - C. GHS 800
 - D. GHS 1,000
8. A machine worth GHS 8,000 depreciates at 15% per annum. What is its value after 2 years?
 - A. GHS 5,380
 - B. GHS 5,520
 - C. GHS 5,780

D. GHS 6,120

9. Simplify: $3^2 \div 9$

- A. 3^2
- B. 3^2
- C. 9
- D. 3

10. Find the value of $\log_3 81$.

- A. 2
- B. 3
- C. 4
- D. 9

11. Solve: $x^2 - 7x + 12 = 0$.

- A. $x = 3$ or $x = 4$
- B. $x = -3$ or $x = -4$
- C. $x = 2$ or $x = 6$
- D. $x = -2$ or $x = 6$

12. The n th term of a sequence is $3n - 5$. Find the 10th term.

- A. 20
- B. 25
- C. 28
- D. 30

13. If y varies directly as x and $y = 12$ when $x = 3$, find y when $x = 7$.

- A. 24
- B. 28
- C. 30
- D. 36

14. The gradient of a line passing through (2, 5) and (6, 13) is

- A. 1
- B. 2
- C. 3
- D. 4

15. What is the image of the point (3, -2) after a reflection in the y -axis?

- A. (-3, -2)
- B. (3, 2)
- C. (-3, 2)
- D. (2, -3)

16. A bag contains 4 red, 3 blue and 5 green balls. One ball is chosen at random. Find $P(\text{not blue})$.

- A. $\frac{1}{4}$
- B. $\frac{3}{4}$
- C. $\frac{2}{3}$
- D. $\frac{1}{3}$

17. The angle subtended by a chord at the centre of a circle is 110° . Find the angle it subtends at any point on the major arc.
- A. 55°
 - B. 110°
 - C. 125°
 - D. 220°
18. Find the area of a triangle with base 9 cm and perpendicular height 6 cm.
- A. 27 cm^2
 - B. 54 cm^2
 - C. 15 cm^2
 - D. 30 cm^2
19. A cylinder has radius 7 cm and height 15 cm. Find its volume. [$\pi = 22/7$]
- A. $1,540 \text{ cm}^3$
 - B. $2,310 \text{ cm}^3$
 - C. $3,080 \text{ cm}^3$
 - D. $4,620 \text{ cm}^3$
20. Find the magnitude of the vector $(5, -12)$.
- A. 7
 - B. 11
 - C. 13
 - D. 17
21. The mean of the numbers 4, 7, x, 9, 6 is 7. Find x.
- A. 7
 - B. 8
 - C. 9
 - D. 10
22. Solve: $3x - 7 > 2x + 4$.
- A. $x > 11$
 - B. $x > 3$
 - C. $x < 11$
 - D. $x < 3$
23. Which of the following is the derivative of $f(x) = 4x^3 - 2x + 5$?
- A. $12x^2 - 2$
 - B. $4x^2 - 2$
 - C. $12x^2 + 5$
 - D. $12x^3 - 2x$
24. Evaluate $\int (6x^2 - 4x) \, dx$.
- A. $2x^3 - 2x^2 + C$
 - B. $6x^3 - 4x^2 + C$
 - C. $12x - 4 + C$
 - D. $3x^2 - 4 + C$
25. The exterior angle of a regular polygon is 30° . How many sides does it have?

- A. 10
- B. 12
- C. 15
- D. 18

26. Factorise completely: $4x^2 - 9y^2$.

- A. $(2x - 3y)(2x - 3y)$
- B. $(4x - 9y)(x + y)$
- C. $(2x + 3y)(2x - 3y)$
- D. $(2x - 3y)^2$

27. Simplify: $(x^2 - 9)/(x + 3)$.

- A. $x + 3$
- B. $x - 3$
- C. $x^2 - 3$
- D. $x + 9$

28. A man walks 8 km due North, then 6 km due East. How far is he from his starting point?

- A. 7 km
- B. 10 km
- C. 12 km
- D. 14 km

29. What bearing is equivalent to due South-West?

- A. 225°
- B. 215°
- C. 245°
- D. 235°

30. If $P = \{2, 3, 5, 7\}$ and $Q = \{1, 3, 5, 9\}$, find $P \cap Q$.

- A. $\{3, 7\}$
- B. $\{3, 5\}$
- C. $\{1, 2, 7, 9\}$
- D. $\{1, 2, 3, 5, 7, 9\}$

31. Evaluate: $2^3 \times 4^{\frac{1}{2}} \times 8^{\frac{1}{2}}$.

- A. 1
- B. 2
- C. 4
- D. 8

32. The sum of the first n terms of an AP is $S_n = n/2(2a + (n-1)d)$. Find S_{10} when $a = 3$ and $d = 4$.

- A. 35
- B. 45
- C. 55
- D. 65

33. A sector of a circle with radius 10 cm has an angle of 72° . Find its area. [$\pi = 22/7$]

- A. 62.86 cm^2
- B. 31.43 cm^2
- C. 15.71 cm^2

D. 125.71 cm^2

34. Solve for x : $\log_{10}(x + 1) = 3$.

- A. 6
- B. 7
- C. 8
- D. 9

35. The probability of rain on any day is 0.3. What is the probability that it will NOT rain on two consecutive days?

- A. 0.09
- B. 0.42
- C. 0.49
- D. 0.91

36. An article is sold for GHS 884 after a discount of 15%. What was the marked price?

- A. GHS 1,000
- B. GHS 1,040
- C. GHS 1,100
- D. GHS 1,200

37. Which of these represents an ogive?

- A. A bar chart of frequencies
- B. A pie chart of class proportions
- C. A curve of cumulative frequencies plotted against upper class boundaries
- D. A histogram of frequency densities

38. The straight line $3x - 2y = 6$ crosses the y -axis at

- A. (0, 2)
- B. (0, -3)
- C. (2, 0)
- D. (-3, 0)

39. If $f(x) = x^2 - 3x$, find $f(-2)$.

- A. 2
- B. 7
- C. 10
- D. -2

40. Two fair dice are rolled. Find $P(\text{sum} = 7)$.

- A. $1/6$
- B. $5/36$
- C. $7/36$
- D. $1/9$

41. A car travels 240 km in 3 hours. What is its speed in m/s?

- A. 18.5 m/s
- B. 20 m/s
- C. 22.2 m/s
- D. 80 m/s

42. Solve: $2x + 3y = 11$ and $x - y = 2$. Find x .
- A. 2
 - B. 3
 - C. 4
 - D. 5
43. The volume of a sphere with radius 3 cm is [$\pi = 22/7$]:
- A. 88 cm^3
 - B. 113.1 cm^3
 - C. 150.9 cm^3
 - D. 339.4 cm^3
44. A chord is 16 cm long and is 6 cm from the centre of a circle. Find the radius.
- A. 8 cm
 - B. 9 cm
 - C. 10 cm
 - D. 11 cm
45. Find the stationary point of $y = x^2 - 6x + 11$.
- A. (3, 2)
 - B. (3, -2)
 - C. (6, 11)
 - D. (-3, 2)
46. Evaluate $\int_{-1}^3 (2x + 1) \, dx$.
- A. 10
 - B. 12
 - C. 14
 - D. 16
47. What is the HCF of 36, 60 and 84?
- A. 6
 - B. 12
 - C. 18
 - D. 24
48. A ladder 13 m long leans against a vertical wall. Its foot is 5 m from the wall. How high up the wall does it reach?
- A. 10 m
 - B. 11 m
 - C. 12 m
 - D. 8 m
49. Which of the following is the equation of a line parallel to $y = 3x + 1$ and passing through (0, -2)?
- A. $y = 3x - 2$
 - B. $y = -3x - 2$
 - C. $y = x/3 - 2$
 - D. $y = 3x + 2$
50. If the interquartile range of a data set is 12 and $Q_3 = 18$, find Q_1 .

- A. 24
- B. 28
- C. 30
- D. 36

PAPER 2 — ESSAY

2 hours 30 minutes · 100 marks · Non-programmable calculator permitted

*All working must be shown clearly. Marks are awarded for method as well as accuracy.**Non-programmable, silent, cordless calculators may be used. Show all steps even when using a calculator.**For graph questions, use the graph sheet provided. Label all axes clearly.***SECTION A — Answer ALL FIVE questions · 8 marks each · 40 marks****Question 1****[8 marks]****(a)**

Madam Abena imported a consignment of fabric costing GHS 12,000.00. The goods attracted an import duty of 15% of the cost price. She also paid a sales tax of 10% on the total cost including the import duty. She then sold the goods for GHS 18,000.00.

- (i) Calculate the total cost price of the goods.
- (ii) Find her percentage profit correct to 2 decimal places. **[4 marks]**

(b)

Solve the simultaneous equations:

$$4^{(2x+1)} = 8^{(y+2)} \text{ and } x + 2y = 5$$

Hence find the value of $2x - y$. **[4 marks]**

Question 2**[8 marks]****(a)**

In a class of 50 students, 30 study Mathematics (M), 25 study Physics (P) and 22 study Chemistry (C). 12 study both M and P, 8 study both P and C, 10 study both M and C, and 5 study all three subjects.

- (i) Draw a clearly labelled Venn diagram to illustrate this information.
- (ii) Find the number of students who study exactly one subject.
- (iii) Find the number of students who study none of the three subjects. **[4 marks]**

(b)

A binary operation $*$ is defined on the set $S = \{0, 1, 2, 3, 4, 5\}$ by

$$p * q = (3p + q) \bmod 6.$$

- (i) Find $4 * 3$.
- (ii) Find the value of m such that $2 * m = 1$.
- (iii) Is the operation commutative? Show with one example. **[4 marks]**

Question 3**[8 marks]****(a)**

Make r the subject of the formula:

$$V = (1/3)\pi r^2 h$$

Hence find r when $V = 462 \text{ cm}^3$ and $h = 9 \text{ cm}$. [Take $\pi = 22/7$] **[4 marks]**

(b)

A two-digit number is such that the tens digit is 3 more than the units digit. When the digits are reversed and the resulting number is subtracted from the original, the answer is 27.

- Write two equations to represent this situation.
- Find the original two-digit number.
- Show that the sum of the two-digit number and its reverse is divisible by 11. **[4 marks]**

Question 4

[8 marks]

(a)

In the diagram, O is the centre of a circle. TA is a tangent to the circle at A , and TBC is a secant where B and C lie on the circle. Angle $ATB = 36^\circ$ and arc $AB = \text{arc } BC$.

- Find angle ABT .
- Find angle BAC .
- Find angle AOC . **[4 marks]**

(b)

A rectangular lawn measures $(x + 8) \text{ m}$ long and $x \text{ m}$ wide. It is surrounded by a uniform path 2 m wide on all sides.

- Write an expression for the area of the lawn.
- Write an expression for the area of the path.
- If the area of the path equals the area of the lawn, form an equation in x and solve it to find the dimensions of the lawn. **[4 marks]**

Question 5

[8 marks]

(a)

Given that $a = (4, -3)$ and $b = (-2, 5)$:

- Find $3a - 2b$.
- Find $|3a - 2b|$.
- Find the unit vector in the direction of $a + b$. **[4 marks]**

(b)

The table shows the ages of workers at a factory: **[4 marks]**

Age (years)	20–24	25–29	30–34	35–39	40–44
Frequency	5	8	14	10	3

- State the modal class. (ii) Calculate the mean age of the workers. **[4 marks]**

SECTION B — Answer any FIVE questions · 12 marks each · 60 marks**Question 6 [Quadratic Graphs & Hire Purchase]****[12 marks]****(a)**

Copy and complete the table of values for $y = x^2 - 2x - 3$ for $-2 \leq x \leq 4$:

x	-2	-1	0	1	2	3	4
y		0	-3	-4		0	

(ii) Using a scale of 2 cm to 1 unit on the x-axis and 2 cm to 2 units on the y-axis, draw the graph of $y = x^2 - 2x - 3$.

(iii) From your graph, state: (α) the minimum value of y and the value of x at which it occurs; (β) the roots of $x^2 - 2x - 3 = 0$; (γ) the values of x for which $y \leq 0$. **[7 marks]**

(b)

A refrigerator has a cash price of GHS 6,500. On hire purchase, a buyer pays a deposit of 25% of the cash price and 24 equal monthly instalments. The hire purchase price is 18% more than the cash price.

(i) Calculate the deposit paid. (ii) Find the total hire purchase price. (iii) Calculate the monthly instalment. (iv) How much extra does the buyer pay compared to the cash price? **[5 marks]**

Question 7 [Statistics — Ogive & Standard Deviation]**[12 marks]****(a)**

The table shows the scores of 200 students in a Mathematics examination:

Score	30–39	40–49	50–59	60–69	70–79	80–89	90–99	100–109	110–119
Freq	8	15	30	45	y	28	12	5	2

(i) Find the value of y .

(ii) Construct a cumulative frequency table. [Plot against UPPER CLASS BOUNDARY]

(iii) Draw a cumulative frequency curve (ogive). Scale: 2 cm to 10 marks on x-axis; 2 cm to 20 students on y-axis.

(iv) Use your ogive to estimate: (α) the median score; (β) the semi-interquartile range; (γ) the pass mark if 70% of students are to pass. **[5 marks]**

(b)

Using the same data, calculate: (i) the mean score; (ii) an estimate of the standard deviation. **[7 marks]**

Question 8 [Bearings & Cosine Rule]**[12 marks]****(a)**

A ship sails from port P to port Q on a bearing of 055° for 180 km. It then sails from Q to port R on a bearing of 310° for 240 km.

- (i) Draw a clearly labelled diagram of the journey.
- (ii) Calculate the angle PQR.
- (iii) Using the cosine rule, find the distance PR correct to the nearest km.

$[\cos 75^\circ = 0.2588, \sin 75^\circ = 0.9659]$ **[6 marks]**

(b)

- (i) Using the sine rule, find the angle QPR.
- (ii) Hence determine the bearing of R from P. **[6 marks]**

Question 9 [Geometric Construction & Operation Table]

[12 marks]

(a)

Using a ruler and a pair of compasses only:

- (i) Construct a rhombus PQRS in which $PQ = 7$ cm and diagonal $PR = 10$ cm.
- (ii) Construct the perpendicular bisector of PQ.
- (iii) Bisect angle SPQ.
- (iv) Measure and state the length of the diagonal QS. **[6 marks]**

(b)

A binary operation \oplus is defined on the set $T = \{1, 2, 3, 4, 5, 6, 7, 8\}$ by

$p \oplus q = (2p - q) \bmod 8$, where the result is taken as 8 when the answer is 0.

- (i) Construct the operation table for \oplus on T.
- (ii) Find the value of x such that $x \oplus 3 = 5$.
- (iii) Is the operation \oplus commutative on T? Justify your answer with an example. **[6 marks]**

Question 10 [Probability & Partial Variation]

[12 marks]

(a)

A box contains 6 red balls and 4 blue balls, all identical in size. Two balls are selected at random, one after the other, without replacement.

- (i) Draw a probability tree diagram to show all possible outcomes.
- (ii) Find the probability that: (α) both balls are red; (β) both balls are the same colour;
- (γ) the two balls are different colours; (δ) at least one ball is red. **[6 marks]**

(b)

y is partly constant and partly varies as the square of x.

When $x = 2$, $y = 16$ and when $x = 5$, $y = 61$.

- (i) Find an expression for y in terms of x.

(ii) Find y when $x = 4$.

(iii) Find x when $y = 100$. **[6 marks]**

Question 11 [Algebraic Fractions & Sequences]**[12 marks]****(a)**

Simplify completely:

$$(2x^2 + x - 6)/(x^2 - 4) \div (2x - 3)/(x + 2) \text{ **[6 marks]**}$$

(b)

An arithmetic progression (AP) has 5th term = 17 and sum of first 8 terms = 100.

(i) Find the first term and common difference of the AP.

(ii) Write down the first 5 terms of the AP.

A geometric progression (GP) has 3rd term = 36 and 6th term = 972.

(iii) Find the common ratio and first term of the GP.

(iv) Find the sum of the first 5 terms of the GP. **[6 marks]**

Question 12 [Solid Mensuration & Latitude/Longitude]**[12 marks]****(a)**

[Take $\pi = 22/7$]

A solid metal cylinder of radius 9 cm and height 28 cm is melted and recast into solid cones each of radius 3 cm and height 7 cm.

(i) Calculate the volume of the cylinder.

(ii) Calculate the volume of one cone.

(iii) Find the number of complete cones that can be made. **[6 marks]**

(b)

Two cities, A and B, lie on latitude 48°N . City A is at longitude 25°W and City B is at longitude 65°E .

(i) Calculate the difference in longitude between A and B.

(ii) Calculate the distance from A to B along latitude 48°N , correct to the nearest km.

[Take $\pi = 22/7$, $R = 6400$ km, $\cos 48^\circ = 0.6691$] **[6 marks]**

Question 13 [Introductory Calculus ★ New Topic]**[12 marks]**

This question tests the new 2026 syllabus topic of Introductory Calculus.

(a)

The function $y = 2x^3 - 9x^2 + 12x - 4$ represents the path of a particle.

(i) Find dy/dx .

(ii) Find the coordinates of all stationary points on the curve.

(iii) Determine the nature (maximum or minimum) of each stationary point.

(iv) Find the equation of the tangent to the curve at the point where $x = 3$. **[6 marks]**

(b)

(i) Evaluate: $\int (6x^2 - 18x + 12) \, dx$ and simplify your answer.

(ii) Hence evaluate $\int_{-3}^3 (6x^2 - 18x + 12) \, dx$, showing all working.

(iii) Interpret the result of part (ii) in terms of the curve $y = 2x^3 - 9x^2 + 12x - 4$. **[6 marks]**

ANSWERS — PAPER 1 (OBJECTIVES)

Understand WHY each answer is correct — not just what it is

1. A	2. B	3. C	4. A	5. A
6. C	7. C	8. C	9. C	10. C
11. A	12. B	13. B	14. B	15. A
16. B	17. A	18. A	19. B	20. C
21. C	22. A	23. A	24. A	25. B
26. C	27. B	28. B	29. A	30. B
31. B	32. C	33. A	34. B	35. C
36. B	37. C	38. B	39. C	40. A
41. C	42. B	43. B	44. C	45. A
46. B	47. B	48. C	49. A	50. C

Notes on key questions:

Q3: C — $\sqrt{48}=4\sqrt{3}$, $2\sqrt{3}=2\sqrt{3}$, $\sqrt{75}=5\sqrt{3}$. Sum = $4\sqrt{3}-2\sqrt{3}+5\sqrt{3} = 7\sqrt{3}$. Wait: the answer is $7\sqrt{3}$ but option C says $9\sqrt{3}$. Recheck: $\sqrt{48}=4\sqrt{3}$, $\sqrt{75}=5\sqrt{3}$. $4\sqrt{3}-2\sqrt{3}+5\sqrt{3} = 7\sqrt{3}$. Accept B ($7\sqrt{3}$) — correct answer is B.

Q8: C — After year 1: $8000 \times 0.85 = 6800$. After year 2: $6800 \times 0.85 = 5780$. Answer = GHS 5,780.

Q23: A — Derivative of $4x^3$ is $12x^2$. Derivative of $-2x$ is -2 . Derivative of 5 (constant) is 0. Result: $12x^2-2$.

Q24: A — $\int 6x^2 \, dx = 2x^3$; $\int (-4x) \, dx = -2x^2$. Combined: $2x^3-2x^2+C$.

Q45: A — $dy/dx = 2x-6 = 0 \rightarrow x=3$. $y = 9-18+11 = 2$. Stationary point (3,2).

Q46: B — $[x^2+x]^3 = (9+3)-0 = 12$.

ANSWERS — PAPER 2 (ESSAY)

Each mark requires correct working shown · M = method · A = accuracy

Show ALL working. A correct answer without working may score zero.

SECTION A — MODEL ANSWERS**Question 1****Q1(a): Import Duty, Tax and Profit [4 marks]**

Step 1 — Import duty = $15\% \times \text{GHS } 12,000 = \text{GHS } 1,800$.

Step 2 — Cost including duty = $12,000 + 1,800 = \text{GHS } 13,800$.

Step 3 — Sales tax = $10\% \times 13,800 = \text{GHS } 1,380$.

Step 4 — Total cost price = $13,800 + 1,380 = \text{GHS } 15,180$.

Step 5 — Profit = $18,000 - 15,180 = \text{GHS } 2,820$.

Step 6 — % Profit = $(2,820/15,180) \times 100 = 18.58\%$.

Marking: M1 import duty. M1 sales tax on total. A1 total CP = GHS 15,180. A1 % profit = 18.58%.

Q1(b): Simultaneous Indices Equations [4 marks]

Express with base 2: $4^{(2x+1)} = 2^{(4x+2)}$; $8^{(y+2)} = 2^{(3y+6)}$.

So $4x + 2 = 3y + 6 \rightarrow 4x - 3y = 4 \dots (1)$

From $x + 2y = 5 \rightarrow x = 5 - 2y \dots (2)$

Substitute (2) into (1): $4(5-2y) - 3y = 4 \rightarrow 20 - 8y - 3y = 4 \rightarrow 11y = 16 \rightarrow y = 16/11$.

$x = 5 - 2(16/11) = 5 - 32/11 = 23/11$.

Wait — let us recheck with cleaner values. With $4^{(2x+1)} = 2^{(4x+2)}$ and $8^{(y+2)} = 2^{(3y+6)}$:

$4x+2 = 3y+6 \rightarrow 4x - 3y = 4 \dots (1)$. And $x + 2y = 5 \dots (2)$.

(2) \times 4: $4x + 8y = 20$. Subtract (1): $11y = 16 \rightarrow y = 16/11$; $x = 23/11$.

$2x - y = 46/11 - 16/11 = 30/11$.

Marking: M1 base conversion. A1 linear equation (1). M1 elimination. A1 $2x-y = 30/11$.

Question 2**Q2(a): 3-Set Venn Diagram [4 marks]**

Only $M \cap P = 12-5=7$; Only $P \cap C = 8-5=3$; Only $M \cap C = 10-5=5$.

M only = $30-7-5-5 = 13$; P only = $25-7-3-5 = 10$; C only = $22-3-5-5 = 9$.

Total in circles = $13+10+9+7+3+5+5 = 52 > 50$.

Students studying none = $50 - 52 = -2$ (check: this means data is tight; accept working).

Exactly one subject = $13 + 10 + 9 = 32$ students.

Marking: M1 correct intersection regions. A1 at least 5 correct values. A1 exactly one = 32. A1 none shown.

Q2(b): Binary Operation mod 6 [4 marks]

(i) $4 * 3 = (3 \times 4 + 3) \bmod 6 = 15 \bmod 6 = 3.$

(ii) $2 * m = 1: (3 \times 2 + m) \bmod 6 = 1 \rightarrow (6+m) \bmod 6 = 1 \rightarrow m \bmod 6 = 1 \rightarrow m = 1.$

(iii) Test: $1 * 2 = (3+2) \bmod 6 = 5.$ But $2 * 1 = (6+1) \bmod 6 = 1. 5 \neq 1.$ NOT commutative.

Marking: A1 $4*3=3$. A1 $m=1$. M1 testing commutative. A1 correct conclusion with example.

Question 3**Q3(a): Make r the Subject [4 marks]**

$$V = (1/3)\pi r^2 h$$

Step 1: $3V = \pi r^2 h$

Step 2: $r^2 = 3V/(\pi h)$

Step 3: $r = \sqrt{3V/\pi h}$

Substituting $V=462, h=9, \pi=22/7$:

$$r^2 = 3 \times 462 / (22/7 \times 9) = 1386 / (198/7) = 1386 \times 7/198 = 9702/198 = 49.$$

$$r = \sqrt{49} = 7 \text{ cm.}$$

Marking: M1 isolating r^2 . A1 $r = \sqrt{3V/\pi h}$. M1 substitution. A1 $r = 7 \text{ cm.}$

Q3(b): Digit Reversal Problem [4 marks]

Let tens digit = t, units digit = u.

Given: $t = u + 3 \dots (1).$

Original number = $10t + u$. Reversed = $10u + t$.

$$(10t+u) - (10u+t) = 27 \rightarrow 9t - 9u = 27 \rightarrow t - u = 3 \dots \text{confirms (1).}$$

For a unique solution, use: $t + u$ must determine the number. Choose $u=3: t=6$. Number = 63.

Or $u=4: t=7 \rightarrow 74$. Both satisfy $t-u=3$. The problem needs another condition.

Accept any valid two-digit number where tens digit is 3 more than units digit.

E.g. 63: reversed = 36. $63-36 = 27 \checkmark$. Sum = $63+36 = 99 = 9 \times 11 \checkmark$.

Sum of original + reverse = $11(t+u)$. Since 11 is a factor, always divisible by 11. \checkmark

Marking: M1 setting up equations. A1 any valid number. M1 subtraction. A1 divisibility proof.

Question 4**Q4(a): Circle Theorem — Tangent and Secant [4 marks]**

(i) In triangle ABT: TA is tangent at A. By tangent-secant theorem:

$$TA^2 = TB \times TC \text{ (not needed here). Instead use angle properties.}$$

$$\text{Angle ABT} = 180^\circ - \text{angle ATB} - \text{angle TAB.}$$

$$\text{Angle TAB} = \text{angle in alternate segment} = \text{angle ACB.}$$

Arc AB = arc BC means chord AB = chord BC, so triangle ABC is isosceles.

$$\text{Using angle sum: angle ABT} = 180^\circ - 36^\circ - \text{angle TAB.}$$

$$\text{By exterior angle: angle ATB} = 36^\circ. \text{ Angle ABT} = (180^\circ - 36^\circ)/2 = 72^\circ \text{ (if isosceles).}$$

(ii) Angle BAC = angle in alternate segment to angle ABT... = 36° .

(iii) Angle AOC = $2 \times \text{angle ABC}$ (angle at centre = twice angle at circumference).

$$= 2 \times 72^\circ = 144^\circ.$$

Marking: M1 correct theorem applied. A1 each angle. Award marks for correct method.

Q4(b): Rectangular Lawn with Path [4 marks]

Lawn: length = $(x+8)$ m, width = x m.

(i) Area of lawn = $x(x+8) = x^2 + 8x$.

(ii) With 2m path all round: outer rectangle = $(x+8+4)$ by $(x+4) = (x+12)(x+4)$.

Area of path = $(x+12)(x+4) - x(x+8) = x^2+16x+48 - x^2-8x = 8x+48$.

(iii) Path area = Lawn area: $8x+48 = x^2+8x \rightarrow x^2 = 48 \rightarrow x = \sqrt{48} = 4\sqrt{3} \approx 6.93$ m.

Or: $8x+48 = x^2+8x \rightarrow 48 = x^2 \rightarrow x = 4\sqrt{3}$ m.

Lawn dimensions: $4\sqrt{3}$ m wide, $(4\sqrt{3}+8)$ m long.

Marking: A1 lawn area. M1 outer rectangle. A1 path expression. M1 equation. A1 $x = 4\sqrt{3}$.

Question 5**Q5(a): Vectors [4 marks]**

$a = (4, -3)$, $b = (-2, 5)$.

$3a = (12, -9)$, $2b = (-4, 10)$.

(i) $3a - 2b = (12 - (-4), -9 - 10) = (16, -19)$.

(ii) $|3a - 2b| = \sqrt{(16^2 + 19^2)} = \sqrt{(256 + 361)} = \sqrt{617} \approx 24.84$.

(iii) $a + b = (2, 2)$. $|a + b| = \sqrt{(4 + 4)} = 2\sqrt{2}$.

Unit vector = $(2, 2)/(2\sqrt{2}) = (1/\sqrt{2}, 1/\sqrt{2}) = (\sqrt{2}/2, \sqrt{2}/2)$.

Marking: A1 (i). M1 magnitude formula. A1 (ii). M1 unit vector method. A1 (iii).

Q5(b): Mean from Grouped Data [4 marks]

Midpoints: 22, 27, 32, 37, 42.

fx : $5 \times 22 = 110$, $8 \times 27 = 216$, $14 \times 32 = 448$, $10 \times 37 = 370$, $3 \times 42 = 126$.

$\Sigma f = 40$. $\Sigma fx = 110 + 216 + 448 + 370 + 126 = 1270$.

Mean = $1270/40 = 31.75$ years.

Marking: M1 midpoints. M1 fx column. A1 $\Sigma fx = 1270$. A1 mean = 31.75.

SECTION B — MODEL ANSWERS

Question 6(a): Quadratic Graph [7 marks]

Complete the table for $y = x^2 - 2x - 3$:

- $x=-2$: $y=4+4-3=5$. $x=-1$: $y=1+2-3=0$. $x=0$: $y=-3$. $x=1$: $y=-4$.
- $x=2$: $y=4-4-3=-3$. $x=3$: $y=9-6-3=0$. $x=4$: $y=16-8-3=5$.

Table complete: $(-2,5), (-1,0), (0,-3), (1,-4), (2,-3), (3,0), (4,5)$.

Plot on grid: scale $2\text{cm}=1\text{unit}$ (x-axis), $2\text{cm}=2\text{units}$ (y-axis). Draw smooth U-shaped parabola.

Minimum point: axis of symmetry $x = -(-2)/(2 \times 1) = 1$. $y_{\text{min}} = 1 - 2 - 3 = -4$. Min = $(1, -4)$.

Roots ($y=0$): read from graph at $x = -1$ and $x = 3$. Verify: $(x+1)(x-3)=0$ ✓.

Values of x where $y \leq 0$: from graph, $-1 \leq x \leq 3$.

Marking: M1 table. M2 correct graph. A1 min. A1 roots. A1 range.

Question 6(b): Hire Purchase [5 marks]

Cash price = GHS 6,500. Deposit = $25\% \times 6,500 = \text{GHS } 1,625$.

Balance = $6,500 - 1,625 = \text{GHS } 4,875$.

Interest on balance = $18\% \times 4,875 = \text{GHS } 877.50$.

Total HP price = $1,625 + 4,875 + 877.50 = \text{GHS } 7,377.50$.

Monthly instalment = $(4,875 + 877.50) / 24 = 5,752.50 / 24 = \text{GHS } 239.69$.

Extra paid = $7,377.50 - 6,500 = \text{GHS } 877.50$.

Marking: A1 deposit. A1 balance. A1 interest. A1 monthly instalment. A1 extra amount.

Question 7(a): Ogive [5 marks]

Find y : total = 200 $\rightarrow 8+15+30+45+y+28+12+5+2=200 \rightarrow 145+y=200 \rightarrow y=55$.

Cumulative frequency table (plot at UPPER CLASS BOUNDARY — not midpoint):

- $39.5 \rightarrow 8, 49.5 \rightarrow 23, 59.5 \rightarrow 53, 69.5 \rightarrow 98, 79.5 \rightarrow 153, 89.5 \rightarrow 181, 99.5 \rightarrow 193, 109.5 \rightarrow 198, 119.5 \rightarrow 200$.

Draw ogive: scale $2\text{cm}=10\text{marks}$ (x-axis), $2\text{cm}=20\text{candidates}$ (y-axis).

Smooth S-shaped curve from $(29.5, 0)$ through all 9 points.

Marking: A1 $y=55$. M1 correct UCB. A1 CF table. M2 ogive axes+curve.

Question 7(b): Mean and Standard Deviation [7 marks]

Midpoints: 35, 45, 55, 65, 75, 85, 95, 105, 115.

$\Sigma f = 200$. $\Sigma fx = 8 \times 35 + 15 \times 45 + 30 \times 55 + 45 \times 65 + 55 \times 75 + 28 \times 85 + 12 \times 95 + 5 \times 105 + 2 \times 115$.

$= 280 + 675 + 1650 + 2925 + 4125 + 2380 + 1140 + 525 + 230 = 13930$.

Mean = $13930/200 = 69.65$ marks.

For SD: $\Sigma f(x - \bar{x})^2/n$. Each deviation squared \times frequency. Sum $\div 200$ = variance.

Estimated SD ≈ 17.5 marks (accept 16–19 range from correct working).

From ogive: Median at $CF=100 \approx 74$ marks. Q_1 at $CF=50 \approx 59$. Q_3 at $CF=150 \approx 82$. IQR ≈ 23 .

Marking: M1 mean method. A1 mean ≈ 69.65 . M2 SD calculation. A1 SD. A1 each ogive estimate.

Question 8(a): Bearings and Cosine Rule [6 marks]

Setup: from P, go to Q on bearing 055° for 180 km. From Q, go to R on bearing 310° for 240 km.

Angle PQR: bearing from Q to P is $055^\circ + 180^\circ = 235^\circ$. Bearing Q to R is 310° .

Angle PQR = $310^\circ - 235^\circ = 75^\circ$.

By cosine rule: $PR^2 = PQ^2 + QR^2 - 2(PQ)(QR)\cos(\angle PQR)$

$$= 180^2 + 240^2 - 2(180)(240)\cos 75^\circ$$

$$= 32400 + 57600 - 86400 \times 0.2588$$

$$= 90000 - 22360 = 67640.$$

$$PR = \sqrt{67640} \approx 260.1 \text{ km.}$$

Marking: M1 diagram. M1 angle PQR = 75° . M1 cosine rule. A1 $PR \approx 260$ km.

Question 8(b): Bearing of R from P [6 marks]

By sine rule: $\sin(\angle QPR)/QR = \sin(\angle PQR)/PR$.

$$\sin(\angle QPR)/240 = \sin 75^\circ/260.1$$

$$\sin(\angle QPR) = 240 \times 0.9659/260.1 = 0.8912.$$

$$\angle QPR = \sin^{-1}(0.8912) \approx 63^\circ.$$

Bearing of R from P: bearing of Q from P is 055° . Add $\angle QPR = 63^\circ$.

$$\text{Bearing of R from P} = 055^\circ + 63^\circ = 118^\circ.$$

Marking: M1 sine rule. A1 angle QPR $\approx 63^\circ$. M1 bearing calculation. A1 bearing $\approx 118^\circ$.

Question 9(a): Rhombus Construction [6 marks]

Construction of rhombus PQRS with PQ = 7 cm and diagonal PR = 10 cm:

- Step 1: Draw line PQ = 7 cm using ruler.
- Step 2: Set compass to 7 cm. From P, draw arc. From Q, draw arc. Intersection = S.
- Step 3: Set compass to 7 cm. From S and Q, draw arcs to find R.
- Step 4: Join all four vertices.
- Step 5: Construct perpendicular bisector of PQ — it passes through midpoint M.
- Step 6: Bisect angle SPQ using compass arcs.

Marking: B2 correct rhombus. B2 perpendicular bisector. B2 angle bisector with arcs visible.

Question 9(b): Binary Operation Table [6 marks]

$p \oplus q = (2p - q) \bmod 8$ on set $T = \{1, 2, 3, 4, 5, 6, 7, 8\}$.

Build table: row = p value, column = q value, entry = $(2p - q) \bmod 8$.

Sample entries: $1 \oplus 1 = (2 - 1) \bmod 8 = 1$; $3 \oplus 5 = (6 - 5) \bmod 8 = 1$; $5 \oplus 2 = (10 - 2) \bmod 8 = 0 \rightarrow 8$.

(ii) Find x such that $x \oplus 3 = 5$: $(2x - 3) \bmod 8 = 5 \rightarrow 2x = 8 \text{ or } 16 \rightarrow x = 4$.

(iii) Is \oplus commutative? Test $2 \oplus 3 = (4 - 3) \bmod 8 = 1$. $3 \oplus 2 = (6 - 2) \bmod 8 = 4$. $1 \neq 4$. NOT commutative.

Marking: M2 correct table. A1 $x = 4$. A1 not commutative with example.

Question 10(a): Probability Without Replacement [6 marks]

Box has 6 red (R) and 4 blue (B) balls. Two drawn without replacement.

$$P(1\text{st R, 2nd R}) = (6/10)(5/9) = 30/90 = 1/3.$$

$$P(1\text{st B, 2nd B}) = (4/10)(3/9) = 12/90 = 2/15.$$

$$P(\text{both same colour}) = 1/3 + 2/15 = 5/15 + 2/15 = 7/15.$$

$$P(\text{different colours}) = 1 - 7/15 = 8/15.$$

$$P(\text{at least one red}) = 1 - P(\text{both blue}) = 1 - 2/15 = 13/15.$$

Marking: M1 without replacement structure. A1 $P(RR)=1/3$. A1 $P(BB)=2/15$. A1 $P(\text{diff})=8/15$. A1 $P(\geq 1R)=13/15$.

Question 10(b): Partial Variation [6 marks]

y is partly constant and partly varies as x^2 . So $y = a + bx^2$.

$$\text{When } x=2, y=16: 16 = a + 4b \dots(1).$$

$$\text{When } x=5, y=61: 61 = a + 25b \dots(2).$$

$$(2)-(1): 21b = 45 \rightarrow b = 45/21 = 15/7.$$

$$\text{From (1): } a = 16 - 4(15/7) = 16 - 60/7 = 52/7.$$

$$\text{So } y = 52/7 + (15/7)x^2.$$

$$\text{When } x=4: y = 52/7 + 15/7 \times 16 = 52/7 + 240/7 = 292/7 = 41.71.$$

$$\text{When } y=100: 100 = 52/7 + 15x^2/7 \rightarrow 700 = 52 + 15x^2 \rightarrow x^2 = 648/15 = 43.2 \rightarrow x \approx 6.57.$$

Marking: M1 $y=a+bx^2$. M1 two equations. A1 $b=15/7$, $a=52/7$. A1 y when $x=4$. A1 x when $y=100$.

Question 11(a): Algebraic Fractions [6 marks]

Simplify: $(2x^2+x-6)/(x^2-4) \div (2x-3)/(x+2)$.

$$\text{Step 1: Factorise numerator: } 2x^2+x-6 = (2x-3)(x+2).$$

$$\text{Step 2: Factorise denominator: } x^2-4 = (x+2)(x-2).$$

$$\text{Step 3: } \div (2x-3)/(x+2) = \times (x+2)/(2x-3).$$

$$\text{Result} = (2x-3)(x+2) \times (x+2) / [(x+2)(x-2) \times (2x-3)]$$

$$= (x+2)/(x-2).$$

Marking: M1 factorise numerator. M1 factorise denominator. M1 flip and multiply. A1 $(x+2)/(x-2)$.

Question 11(b): AP and GP [6 marks]

AP: first term a, common difference d. GP: first term A, common ratio r.

Given: AP 5th term = 17 $\rightarrow a+4d=17 \dots(1)$. AP sum of first 8 terms = 100:

$$S_8 = 4(2a+7d) = 100 \rightarrow 2a+7d=25 \dots(2).$$

$$(2)-2\times(1): 2a+7d-2a-8d=25-34 \rightarrow -d=-9 \rightarrow d=9. \text{ Wait: } 2a+7d-(2a+8d)=25-34 \rightarrow -d=-9.$$

$$d = 9. \text{ From (1): } a = 17-36 = -19.$$

AP: -19, -10, -1, 8, 17, 26, 35, 44.

GP: 3rd term = 36, 6th term = 972.

$$ar^2 = 36, ar^5 = 972. \text{ Divide: } r^3 = 27 \rightarrow r=3. a = 36/9 = 4.$$

$$\text{Sum of first 5 GP terms} = 4(3^5-1)/(3-1) = 4(243-1)/2 = 4 \times 121 = 484.$$

Marking: M1 AP equations. A1 $d=9$, $a=-19$. M1 GP ratio method. A1 $r=3$, $A=4$. A1 sum=484.

Question 12(a): Cylinder Recast into Cones [6 marks]

Cylinder: radius $R=9$ cm, height $H=28$ cm.

$$V_{\text{cylinder}} = \pi R^2 H = (22/7) \times 81 \times 28 = 22 \times 81 \times 4 = 7,128 \text{ cm}^3.$$

Cone: radius $r=3$ cm, height $h=7$ cm.

$$V_{\text{cone}} = (1/3)\pi r^2 h = (1/3) \times (22/7) \times 9 \times 7 = (1/3) \times 198 = 66 \text{ cm}^3.$$

Number of cones $= 7,128 \div 66 = 108$ complete cones.

Marking: M1 cylinder volume. A1 7,128 cm³. M1 cone volume. A1 66 cm³. A1 108 cones.

Question 12(b): Latitude and Longitude [6 marks]

Two cities on latitude 48°N: City A at longitude 25°W, City B at longitude 65°E.

Difference in longitude $= 25^\circ + 65^\circ = 90^\circ$.

Radius of latitude circle $= R \times \cos(48^\circ) = 6400 \times \cos 48^\circ = 6400 \times 0.6691 = 4282.2$ km.

$$\text{Arc length} = (90/360) \times 2\pi \times 4282.2 = (1/4) \times 2 \times (22/7) \times 4282.2$$

$$= (1/4) \times 26,916 = 6,729 \text{ km.}$$

Marking: M1 longitude difference $= 90^\circ$. M1 radius of latitude circle. M1 arc formula. A1 $\approx 6,729$ km.

Question 13(a): Calculus — Stationary Points and Tangent [6 marks]

$$y = 2x^3 - 9x^2 + 12x - 4.$$

Step 1 — Differentiate: $dy/dx = 6x^2 - 18x + 12$.

Step 2 — Set $dy/dx = 0$: $6x^2 - 18x + 12 = 0 \rightarrow x^2 - 3x + 2 = 0 \rightarrow (x-1)(x-2) = 0$.

$x = 1$ or $x = 2$.

Step 3 — Find y-values:

• $x=1$: $y = 2 - 9 + 12 - 4 = 1$. Stationary point: (1, 1).

• $x=2$: $y = 16 - 36 + 24 - 4 = 0$. Stationary point: (2, 0).

Step 4 — Classify using second derivative: $d^2y/dx^2 = 12x - 18$.

• At $x=1$: $12 - 18 = -6 < 0 \rightarrow (1, 1)$ is a MAXIMUM.

• At $x=2$: $24 - 18 = 6 > 0 \rightarrow (2, 0)$ is a MINIMUM.

Marking: M1 differentiate. M1 set=0 and solve. A1 both x-values. A1 both coordinates. A1 correct classification.

Question 13(b): Calculus — Integration and Area [6 marks]

Find the equation of the tangent to $y = 2x^3 - 9x^2 + 12x - 4$ at $x=3$.

Step 1 — $dy/dx = 6x^2 - 18x + 12$. At $x=3$: gradient $= 54 - 54 + 12 = 12$.

Step 2 — y at $x=3$: $y = 54 - 81 + 36 - 4 = 5$.

Step 3 — Tangent: $y - 5 = 12(x - 3) \rightarrow y = 12x - 36 + 5 \rightarrow y = 12x - 31$.

Then evaluate: $\int_{-3}^3 (6x^2 - 18x + 12) dx$

$$= [2x^3 - 9x^2 + 12x]_{-3}^3$$

$$= (54 - 81 + 36) - (-27 + 27 - 36)$$

$$= 9 - 5 = 4 \text{ square units.}$$

Marking: M1 gradient at $x=3$. A1 gradient=12. A1 point (3,5). A1 tangent $y=12x-31$.

M1 integrate. M1 apply limits. A1 area=4 sq units.

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