FORM TP 2024098

TEST CODE **01234020**

MAY/JUNE 2024

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION

MATHEMATICS

Solutions By ;

Paper 02 – General Proficiency

R. Nimai Harrichan.

2 hours 40 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of TWO sections: I and II.
2. Section I has SEVEN questions and Section II has THREE questions.
3. Answer ALL questions, writing your answers in the spaces provided in this booklet.
4. Numerical answers that are non-exact should be given correct to 3 significant figures or 1 decimal place for angles in degrees unless a different level of accuracy is specified in the question.
5. Do NOT write in the margins.
6. All working MUST be clearly shown.
7. **A list of formulae is provided on page 4 of this booklet.**
8. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
9. **If you use the extra page(s), you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**
10. **ALL diagrams in this booklet are NOT drawn to scale, unless otherwise stated.**

Required Examination Materials

Electronic calculator
Geometry set

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

LIST OF FORMULAE

Volume of a prism	$V = Ah$ where A is the area of a cross-section and h is the perpendicular length.
Volume of a cylinder	$V = \pi r^2 h$ where r is the radius of the base and h is the perpendicular height.
Volume of a right pyramid	$V = \frac{1}{3} Ah$ where A is the area of the base and h is the perpendicular height.
Circumference	$C = 2\pi r$ where r is the radius of the circle.
Arc length	$S = \frac{\theta}{360} \times 2\pi r$ where θ is the angle subtended by the arc, measured in degrees.
Area of a circle	$A = \pi r^2$ where r is the radius of the circle.
Area of a sector	$A = \frac{\theta}{360} \times \pi r^2$ where θ is the angle of the sector, measured in degrees.
Area of a trapezium	$A = \frac{1}{2}(a + b)\, h$ where a and b are the lengths of the parallel sides and h is the perpendicular distance between the parallel sides.

Roots of quadratic equations — If $ax^2 + bx + c = 0$,

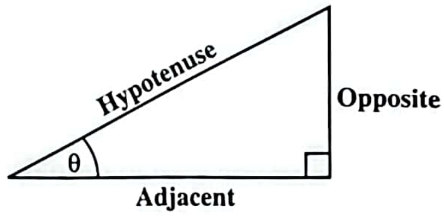
then $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Trigonometric ratios

$\sin \theta = \dfrac{\text{length of opposite side}}{\text{length of hypotenuse}}$

$\cos \theta = \dfrac{\text{length of adjacent side}}{\text{length of hypotenuse}}$

$\tan \theta = \dfrac{\text{length of opposite side}}{\text{length of adjacent side}}$

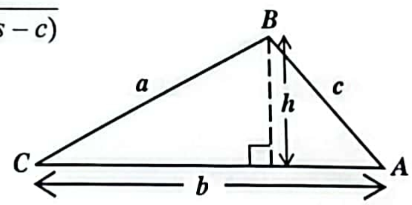


Area of a triangle — Area of $\Delta = \frac{1}{2} bh$ where b is the length of the base and h is the perpendicular height.

Area of $\Delta\, ABC = \frac{1}{2} ab \sin C$

Area of $\Delta\, ABC = \sqrt{s(s-a)(s-b)(s-c)}$

where $s = \dfrac{a+b+c}{2}$



Sine rule — $\dfrac{a}{\sin A} = \dfrac{b}{\sin B} = \dfrac{c}{\sin C}$

Cosine rule — $a^2 = b^2 + c^2 - 2bc \cos A$

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SECTION I

Answer ALL questions.

All working MUST be clearly shown.

1. (a) (i) Calculate the value of $\sqrt{(7.1)^2 + (2.9)^2}$, giving your answer correct to

a) 2 significant figures

$\sqrt{(7.1)^2+(2.9)^2} = 7.669419796$

7.7

(1 mark)

b) 2 decimal places.

7.67

(1 mark)

(ii) Write the following quantities in ascending order.

$\frac{12}{25}$, 0.46, 47%

0.48 0.47

0.46 < 47% < 12/25

(1 mark)

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(b) Mahendra and Jaya shared $7 224 in the ratio 7:5. How much MORE money does Mahendra receive than Jaya?

12 parts = \$ 7224 ⇒ 1 part = $\frac{7224}{12}$ = 602 \$

M − J = (7 × 602 \$) − (5 × 602 \$)

\$1204 ....

(2 marks)

(c) The present population of Portmouth is 550 000. It is expected that this population will increase by 42% by the year 2030.

(i) Write the number 550 000 in standard form.

550 000

5.5×10^5 ....

(1 mark)

(ii) Calculate the expected population of Portmouth in 2030.

$\frac{142}{\cancel{100}} \times \frac{550{,}0\cancel{00}}{1} = 781\,000$

781000 ....

(1 mark)

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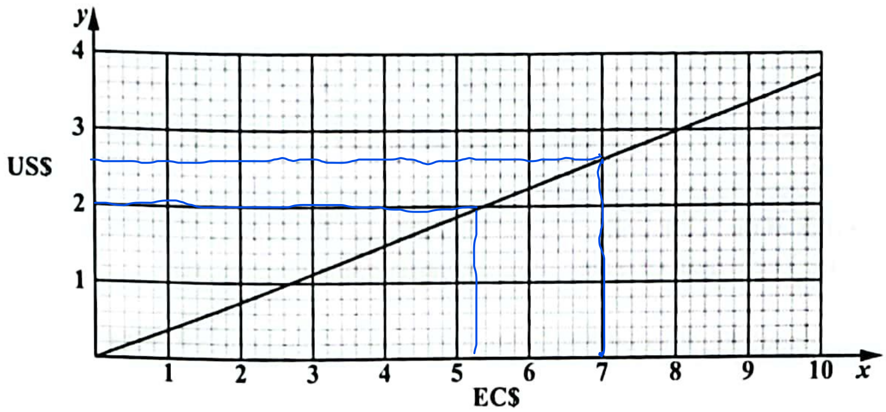
(d) The graph below can be used to convert between United States dollars (US$) and Eastern Caribbean dollars (EC$).



Using the graph,

(i) convert US$2 to EC$.

From graph as shown;

$ 5.20

(1 mark)

(ii) convert EC$70 to US$.

From graph : $7EC = $ 2.60 US

x10] $70EC = $26US

$26USD.

(1 mark)

Total 9 marks

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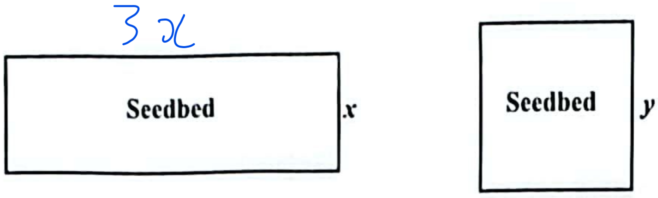
2. Laura needs to put mesh around **two** seedbeds to protect her seedlings. **Altogether,** she uses 60 m of mesh. One of the seedbeds is a rectangle and the other is a square, as shown in the diagram below.



The width of the rectangular seedbed is x metres. The length of the rectangular seedbed is 3 times its width. The length of a side of the square seedbed is y metres.

(a) Using the information given above, derive a simplified expression for y in terms of x.

$3x + 3x + x + x + 4y = 60$

$8x + 4y = 60$

$4y = 60 - 8x$

$y = 15 - 2x$

(2 marks)

(b) The area of the rectangular seedbed is **equal** to the area of the square seedbed.

(i) Use this information and your answer in (a) to write down a quadratic equation, in terms of x, and show that it simplifies to

$$x^2 - 60x + 225 = 0.$$

$A_{square} = A_{rec}$

$S \times S = L \times B$

$\Rightarrow (15-2x)^2 = 3x \times x$

$\Rightarrow 225 - 60x + 4x^2 = 3x^2$

$\Rightarrow x^2 - 60x + 225$ ☐

(2 marks)

(ii) Solve the equation $\overset{a}{x^2} - \overset{b}{60x} + \overset{c}{225} = 0$ using the quadratic formula.

Recall; $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$x = \dfrac{60 \pm \sqrt{(-60)^2 - 4(225)}}{2}$

$x_1 = 30 + 15\sqrt{3}$ ∧ $x_2 = 30 - 15\sqrt{3}$ ☐

(3 marks)

(iii) Calculate the TOTAL area of the **two** seedbeds.

Recall: $y = 15 - 2x$

$y = 15 - 2(30 + 15\sqrt{3})$

$y = (-45 - 30\sqrt{3})$

or $y = (-45 + 30\sqrt{3})$

Area $= A(x, y) = 3x^2 + y^2$

Area $= 3(30 \pm 15\sqrt{3})^2 + (-45 \mp 30\sqrt{3})^2$

$= 18803.07436 \text{ units}^2 + 96.92563913 \text{ units}^2$

(2 marks)

$= 18,900 \text{ m}^2$ ☐

Total 9 marks

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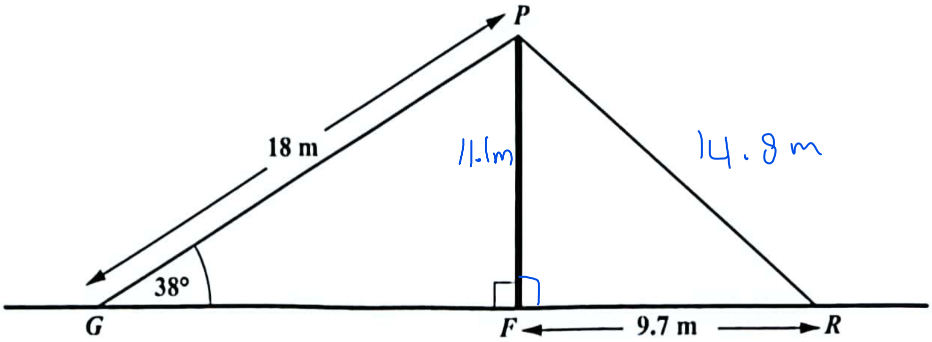
3. (a) A vertical flagpole, FP, stands on horizontal ground and is held by two ropes, PG and PR, as shown in the diagram below.

$PG = 18$ m, $FR = 9.7$ m and angle $FGP = 38°$.



(i) Calculate the height of the flagpole, FP.

$\sin\theta = \frac{O}{H} \Rightarrow \sin 38 = \frac{FP}{18}$

$\Rightarrow 18\sin 38 = FP$

$\Rightarrow FP = 11.1\text{m}$

11.1m

(2 marks)

(ii) Find PR, the length of one of the pieces of rope used to hold the flagpole.

$PR^2 = (11.1)^2 + (9.7)^2$

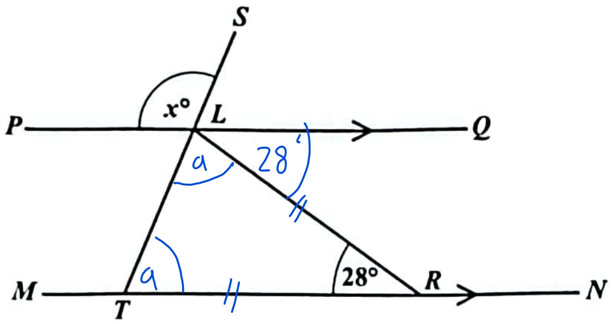
$PR = \sqrt{(11.1)^2 + (9.7)^2}$

$PR = 14.8\text{m}$

14.8m

(2 marks)

(b) In the diagram below, PQ is parallel to MN, LRT is an isosceles triangle and SLT is a straight line.



Find the value of x.

From Δ LRT : $180° = 28° + 2a$

$180° - 28° = 2a$

$152° = 2a$

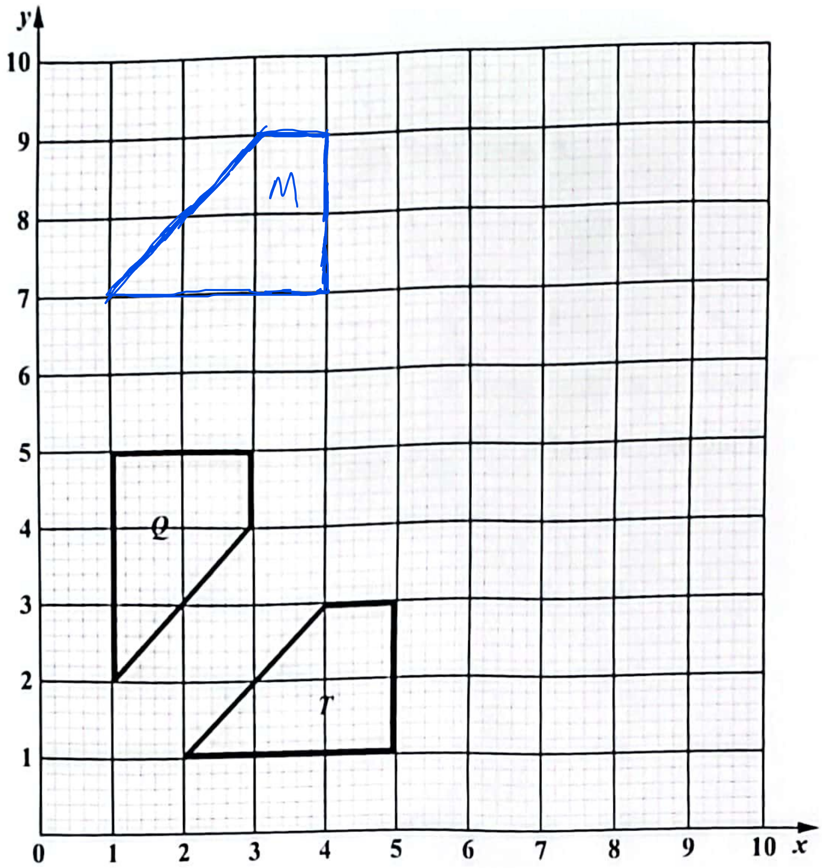
$a = 76°$

Since $a = 76°$, $x = 76°$

$76°$

(2 marks)

(c) The diagram below shows a shape, T, and its image, Q, after a transformation.



(i) Describe fully the **single** transformation that maps Shape T onto Shape Q.

A reflection along the line $y = x$ accurately describes the transformation.

(2 marks)

(ii) On the diagram above, draw the image of Shape T after it undergoes a translation by the vector $\begin{pmatrix} -1 \\ 6 \end{pmatrix}$. Label this image M. **(1 mark)**

Total 9 marks

4. (a) A rectangle, $PQRS$, has a diagonal, PR, where P is the point $(-3, 10)$ and R is the point $(4, -4)$.

$x_1 \; y_1$

$x_2 \; y_2$

(i) Calculate the length of the line PR.

$|RR| = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$

$= \sqrt{(4+3)^2 + (-4-10)^2} = \sqrt{(7)^2+(-14)^2}$

$= 7\sqrt{5}$

(2 marks)

(ii) Determine the equation of the line PR.

$M_{PR} = \dfrac{y_2-y_1}{x_2-x_1} = \dfrac{-4-10}{4+3} = \dfrac{-14}{7} = -2$

Using $m = -2$ and $P(\overset{x_1}{-3}, \overset{y_1}{10})$: $y - y_1 = m(x - x_1)$

$\Rightarrow y - 10 = -2(x+3)$

$\Rightarrow y - 10 = -2x - 6$

$y = -2x - 6 + 10$

(3 marks)

$y = -2x + 4$

(b) Two functions, f and g, are defined as follows.

$$f(x) = 3x + 1 \quad \text{and } g(x) = x^2.$$

Find, in its simplest form, an expression for

(i) $f(x - 2)$

$f(x-2) = 3(x-2) + 1$

$= 3x - 6 + 1$

$f(x-2) = 3x - 5$ ▫

(2 marks)

(ii) $g(\underset{}{\overset{f(x)}{3x + 2}}) + 10.$

$\Rightarrow (3x+2)^2 + 10$

$\Rightarrow (3x+2)(3x+2) + 10$

$\Rightarrow 9x^2 + 6x + 6x + 4 + 10$

$\Rightarrow 9x^2 + 12x + 14$ ▫

(2 marks)

Total 9 marks

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5. (a) Mr Morgan administered a spelling test to his class. The table below shows the number of words out of 10 that each student spelt correctly.

x	**Number of Words**	5	6	7	8	9	10
f	**Frequency**	8	4	2	2	3	4

(i) For the data set shown above, state the

a) mode

5words is the mode sihe it ocurs the most frequent

5words

(1 mark)

b) median.

5,5,5,5,5,5,5,5, 6,6,6,6, 7,7, 8,8, 9,9,9, 10,10,10,10

↑middle

6

(1 mark)

(ii) Calculate the mean number of words spelt correctly.

$$\bar{x} = \frac{\Sigma fx}{\Sigma f} = \frac{40+24+14+16+27+40}{23}$$

$$\bar{x} = \frac{161}{23} = 7 \text{ words}$$

7 words

(2 marks)

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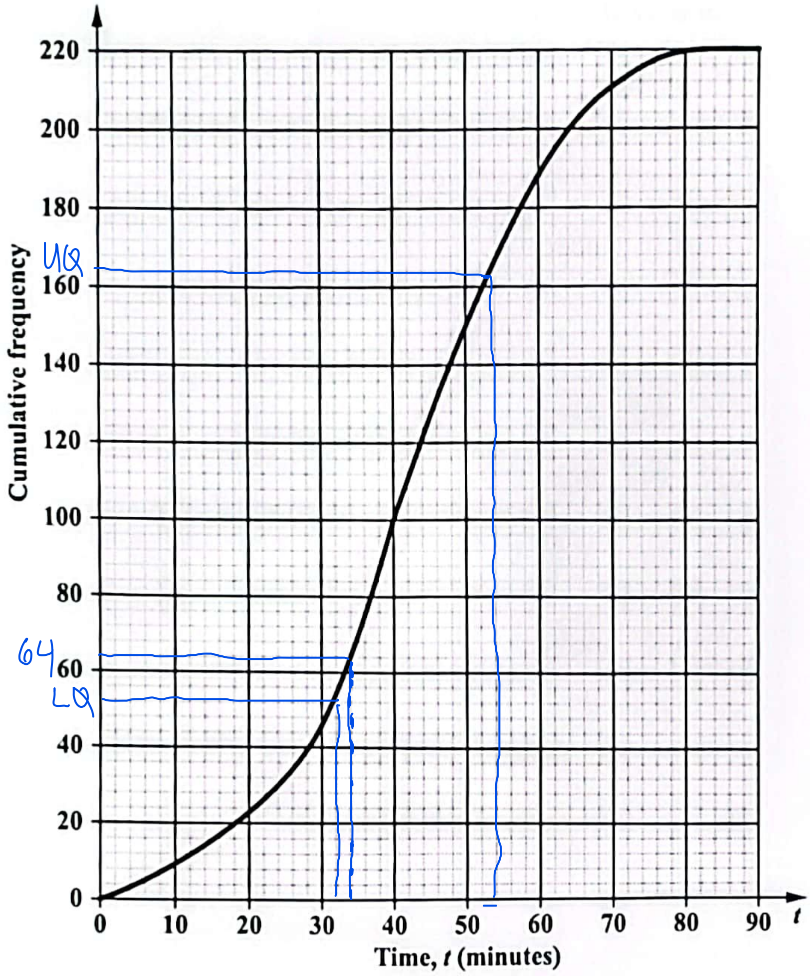
(b) The attendance officer at a particular school recorded the time, t, in minutes, taken by each student in a group to travel to school. The data collected is shown on the cumulative frequency curve below.



Using the cumulative frequency curve, find an estimate of

(i) the number of students who took at MOST 32 minutes to travel to school

64 students

(1 mark)

(ii) the inter-quartile range.

$$IQR = UQ - LQ$$
$$= 54 - 32$$
$$= 22 \text{ mins}$$

22mins

(2 marks)

(c) The letters in the word "POSITIVITY" are each written on separate cards and placed in a bag. Dacia picks 2 of these cards, at random, **with replacement**.

P	O	S	I	T	I	V	I	T	Y
1	2	3	4	5	6	7	8	9	10

Find the probability that she picks the letter "I" then the letter "V".

$$P(I \text{ then } V) = \frac{3}{10} + \frac{1}{10} = \frac{4}{10}$$

P(I) P(V)

4/10

(2 marks)

Total 9 marks

6. [In this question, take $\pi = \frac{22}{7}$.]

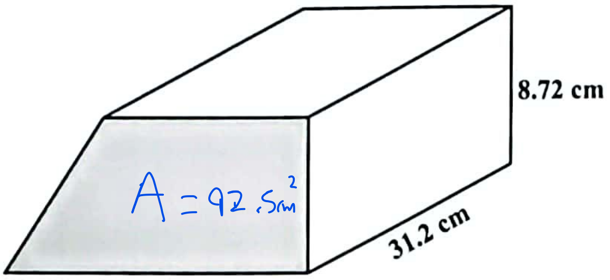
(a) The diagram below shows a gold bar in the shape of a trapezoidal prism. Its volume is 2 886 cm³. The length and height of the prism are indicated on the diagram.

$V = A \times 31.2$

$\Rightarrow A = \frac{V}{31.2}$

$\Rightarrow A = \frac{2886}{31.2}$

$A = 92.5\,cm^2$



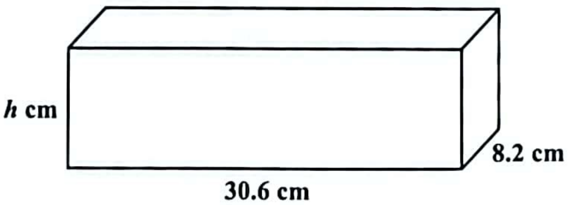
(i) Calculate the area of the **shaded** cross-section of the trapezoidal prism.

$92.5\,cm^2$

....

(1 mark)

(ii) The cuboid-shaped gold bar shown below has the same volume as the trapezoidal prism-shaped gold bar displayed at (a).



Calculate the height, *h*, of the cuboid-shaped gold bar.

$V_{Trapezoid} = V_{cuboid}$; $2886 = 30.6 \times 8.2 \times h$

$\Rightarrow h = \frac{2886}{30.6 \times 8.2}$

$11.5\,cm$

....

(2 marks)

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(b) The trapezoidal gold bar is melted down and **all** the gold is used to make SIX identical spheres.

Calculate, for EACH sphere of gold, its

(i) radius

[The volume, V, of a sphere with radius, r is $V = \frac{4}{3}\pi r^3$.]

$2886 = 6 V_s$; $2886 = 6 \cdot \frac{4}{3} \pi r^3$

$2886 = \frac{24}{3} \pi r^3$

$2886 = 8 \pi r^3$

$\Rightarrow 2886 = 8\left(\frac{22}{7}\right) r^3$; $2886 = \frac{176}{7} r^3$

$\Rightarrow 2886 \times \frac{7}{176} = r^3 = \frac{10101}{88} \Rightarrow r = \sqrt[3]{\frac{10101}{88}}$

$= 4.86 cm$

$r = 4.86 cm$

(3 marks)

(ii) surface area

[The surface area, A, of a sphere with radius r, $A = 4\pi r^2$.]

$SA = 4 \times \frac{22}{7} \times (4.86)^2$

$= 296.9 cm^2$

$296.9 cm^2$

(1 mark)

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(iii) mass, **to the nearest kilogram**, given that the density of gold is $\underbrace{19.3 \text{ g/cm}^3}$.

$\hookrightarrow$ 0.193 kg/cm^3

$$\left(\text{Density} = \frac{\text{mass}}{\text{volume}}\right)$$

$\rho = \frac{m}{v} \Rightarrow m = \rho \times v$

$m = 0.193 \times \left(\frac{22}{7} \times \frac{4}{3} \times (4.86)^3\right)$

$m = 92.87\text{kg}$

92.87kg

(2 marks)

Total 9 marks

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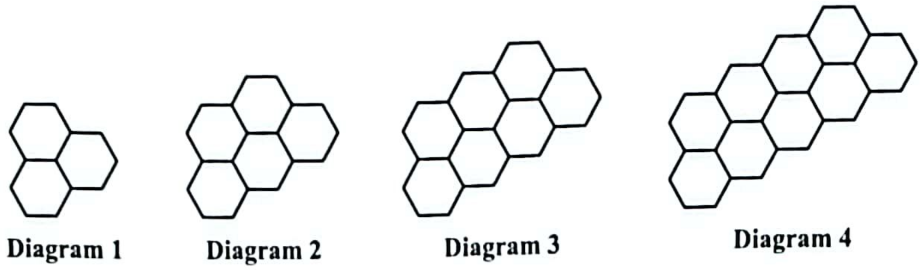
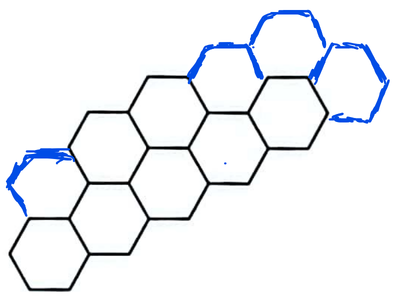
7. The diagram below shows the first four diagrams in a sequence of regular hexagons. Each regular hexagon is made using sticks of unit length.



(a) Complete the diagram below to represent Diagram 5 in the sequence of regular hexagons.



(2 marks)

(b) The number of regular hexagons, H, the number of sticks, S, and the perimeter of each figure, P, follow a pattern. The values for H, S and P, for the first 4 diagrams are shown in the table below. Study the pattern of numbers in each row of the table and answer the questions that follow.

Complete the rows marked (i), (ii) and (iii) in the table below.

$2n+1=47$

$2n=46$

$n=23$

	Diagram Number (D)	Number of Hexagons (H)	Number of Sticks (S)	Perimeter (P)	
	1	3	15	12	
	2	5	23	16	
	3	7	31	20	
	4	9	39	24	
(i)	5	11	47	28	(2 marks)
	⋮	⋮	⋮	⋮	
(ii)	23	47	191	....	(2 marks)
	⋮	⋮	⋮	⋮	
(iii)	n	$2n+1$	$8n+7$	$12+4(n-1)$	(3 marks)

(c) Skyla says that she can make one of these figures with a perimeter of EXACTLY 1 005. Explain why she is **incorrect**.

$1005=12+4n-4$

$1005-8=4n$

$997=4n$

$n=\frac{997}{4}=249.25$ which is incorrect since perimeter must be positive integers.

(1 mark)

Total 10 marks

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SECTION II

Answer ALL questions.

ALL working MUST be clearly shown.

ALGEBRA, RELATIONS, FUNCTIONS AND GRAPHS

8. (a) The functions f and g are defined as follows.

$$f(x) = \frac{2x-1}{3} \quad \text{and} \quad g(x) = 5 - x^2.$$

(i) Determine the value of

a) $g(2)$

$g(2) = 5 - 2^2$

$= 5 - 4$

$= 1$

(1 mark)

b) $f^{-1}(3)$.

$y = \frac{2x-1}{3} \Rightarrow x = \frac{2y-1}{3}$

$\Rightarrow 3x = 2y - 1$

$\Rightarrow 3x + 1 = 2y \Rightarrow y = \frac{3}{2}x + \frac{1}{2}$

$\Rightarrow f^{-1}(3) = \frac{3}{2}(6) + \frac{1}{2}$

(2 marks)

$= 9.5$

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(ii) Derive an expression, in its simplest form, for $fg(x)$.

$f = \frac{2x-1}{3}$ $g = 5 - x^2$

$fg = \frac{2(5-x^2)-1}{3} = \frac{10-2x^2-1}{3}$

$\Rightarrow \frac{9-2x^2}{3}$

$\Rightarrow \frac{1}{3}\left(x - \frac{3\sqrt{2}}{2}\right)\left(x + \frac{3\sqrt{2}}{2}\right)$

(2 marks)

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(iii) Sketch the graph of the function $g(x)$ in the space provided below. On your sketch, indicate the maximum/minimum point and the roots of the function.

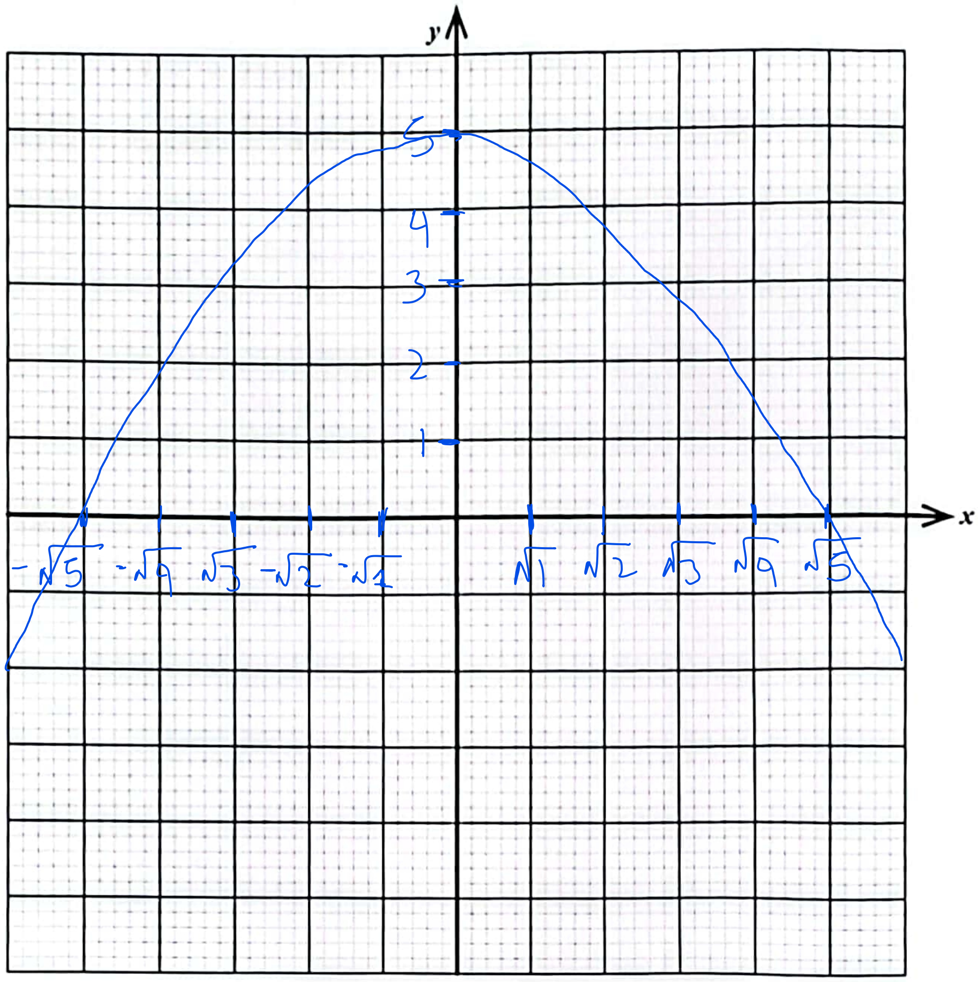
$g = 5 - x^2$

$x = \sqrt{3}$

and

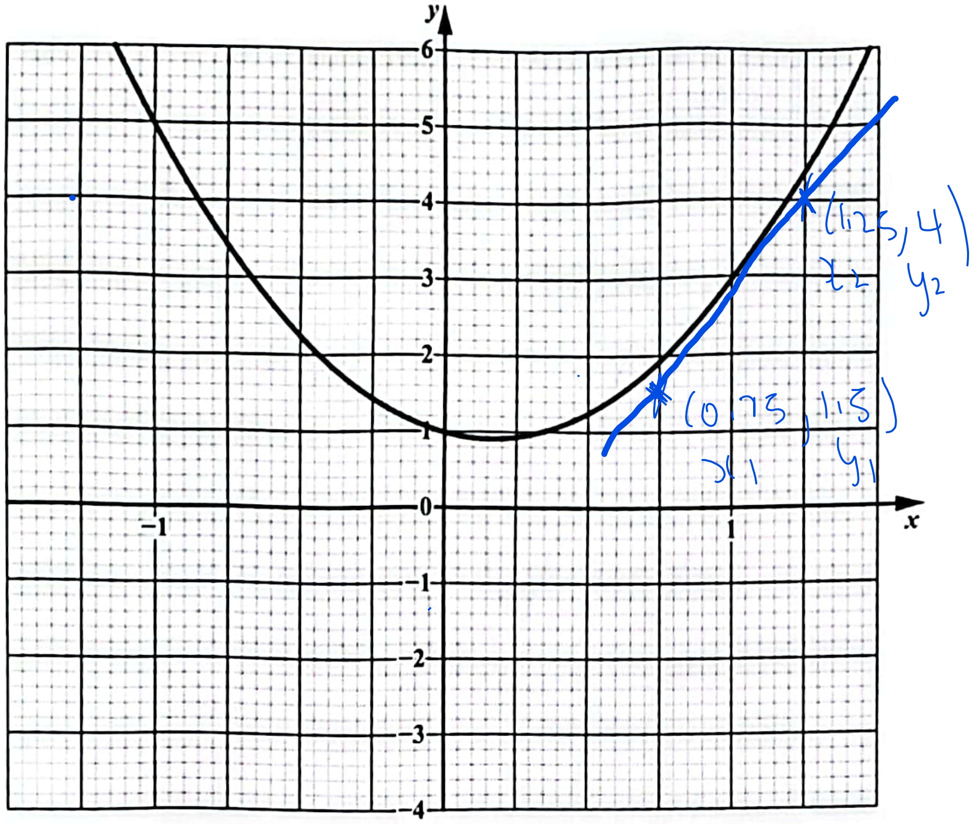
$x = -\sqrt{5}$

y intercept = 5



(3 marks)

(b) The graph below shows a quadratic function.



(i) On the grid above, draw the tangent to the curve at $x = 1$. **(1 mark)**

(ii) Use the tangent drawn to estimate the gradient of the curve at $x = 1$.

$$m = \frac{4 - 1.5}{1.25 - 0.75} = 5$$

5 ....

(2 marks)

(iii) Write down the equation of the tangent in the form $y = mx + c$.

$\begin{pmatrix} x_1 & y_1 \\ 1, & 3 \end{pmatrix}$ and $m = 5 \Rightarrow y - y_1 = m(x - x_1)$

$\Rightarrow y - 3 = 5(x - 1)$

$\Rightarrow y - 3 = 5x - 5$

(1 mark)

$\Rightarrow y = 5x - 2$

Total 12 marks

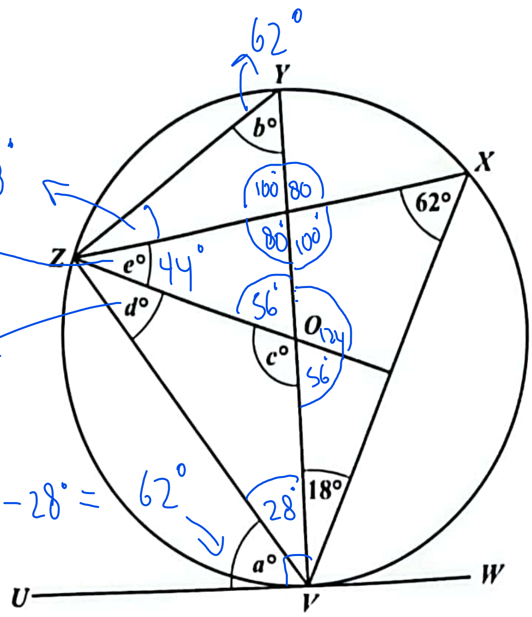
GEOMETRY AND TRIGONOMETRY

9. (a) V, X, Y and Z lie on the circumference of the circle shown below, centre O, with diameter VY. UW is a tangent to the circle at V. Angle $VXZ = 62°$ and Angle $XVY = 18°$.

$e = 180° - (80+56)$

$d = 90° - (44+18) = 28°$

$a = 90° - 28° = 62°$



(i) State a theorem that justifies the values of EACH of the following angles.

a) Angle $b = 62°$

angles at ciramference is equal when bounded by a chord.

(1 mark)

b) Angle $c = 124°$

angle at the contre is twice that of the circumference

(1 mark)

c) Angle $OVW = 90°$

tangent touching a radius or diameter is a 90°

(1 mark)

(ii) Find the values of Angles a, d and e. Show ALL working where appropriate.

$\angle a =$ 90 − 28

= 62°

= 62°

$\angle d =$ 90° − (44+18)

= 28°

$\angle e =$ 180 − (80+56)

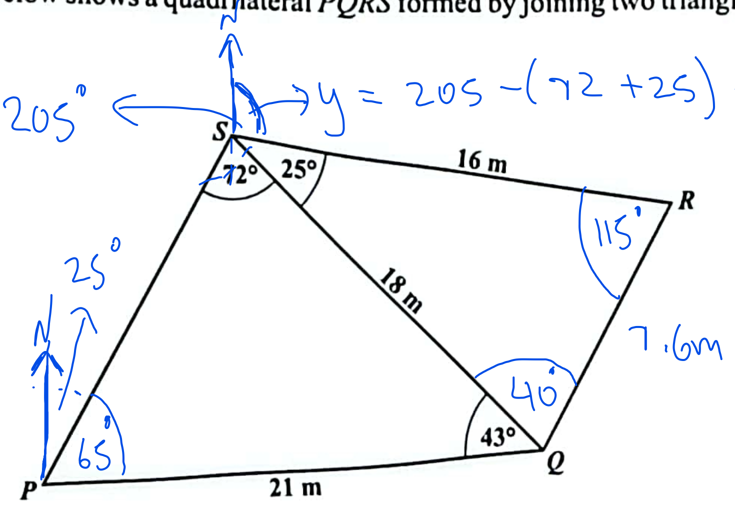
= 44°

44°

(3 marks)

(b) The diagram below shows a quadrilateral *PQRS* formed by joining two triangles, *PQS* and *QRS*.

205° $\rightarrow y = 205 - (72 + 25) = 108^\circ$



(i) Calculate the length of *QR*.

by Cosine Rule;

$x^2 = 16^2 + 18^2 - 2(16 \times 18)\cos 25$

$\Rightarrow QR = \sqrt{16^2 + 18^2 - 2(16 \times 18)\cos 25}$

$\Rightarrow QR = 7.6\text{m}$

....

(3 marks)

(ii) The bearing of P from S is 205°. Determine the bearing of

a) R from S

$205 - (72 + 25) = 108°$

108°

(1 mark)

b) S from P.

$90° - 65° = 25°$

25°

(2 marks)

Total 12 marks

VECTORS AND MATRICES

10. (a) The determinant of the matrix $\begin{pmatrix} 6 & 2v \\ -5 & -v \end{pmatrix}$ is 24.

A

Calculate the value of v.

$\det A = ad - bc$

$\Rightarrow -6v + 10v = 24$

$\Rightarrow 4v = 24$

$\Rightarrow v = 6$

....

(2 marks)

(b) The matrices L and M are defined as follows.

$$L = \begin{pmatrix} 9 & 5 \\ 3 & 2 \end{pmatrix}, \quad M = \begin{pmatrix} 2 \\ -4 \end{pmatrix}.$$

Evaluate EACH of the following.

(i) The matrix product LM

$$\begin{bmatrix} 9 & 5 \\ 3 & 2 \end{bmatrix} \begin{bmatrix} 2 \\ -4 \end{bmatrix} = \begin{bmatrix} 18 - 20 \\ 6 - 8 \end{bmatrix}$$

$$= \begin{bmatrix} -2 \\ -2 \end{bmatrix}$$

....

(2 marks)

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$L = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$ $\begin{pmatrix} d & -b \\ -c & a \end{pmatrix}$

(ii) L^{-1}, the inverse of L

$L = \begin{pmatrix} 9 & 5 \\ 3 & 2 \end{pmatrix} \Rightarrow L^{-1} = \frac{1}{\det(L)} (\text{Adj}\, L)$

$L^{-1} \Rightarrow \begin{pmatrix} 2/3 & -5/3 \\ -1 & 3 \end{pmatrix}$ □

(2 marks)

(c) $\overrightarrow{PQ} = \begin{bmatrix} 5 \\ -4 \end{bmatrix}$.

If P is the point (–2, 3), determine the coordinates of Q.

$OP = \begin{pmatrix} -2 \\ 3 \end{pmatrix}$ $PQ = \begin{pmatrix} 5 \\ -4 \end{pmatrix}$

$\overrightarrow{PQ} = -\overrightarrow{OP} + \overrightarrow{OQ}$

$\Rightarrow \overrightarrow{OQ} = \overrightarrow{PQ} + \overrightarrow{OP} = \begin{pmatrix} 5 \\ -4 \end{pmatrix} + \begin{pmatrix} -2 \\ 3 \end{pmatrix} = \begin{pmatrix} 3 \\ 1 \end{pmatrix}$

Point $Q = (3, 1)$ □

(2 marks)

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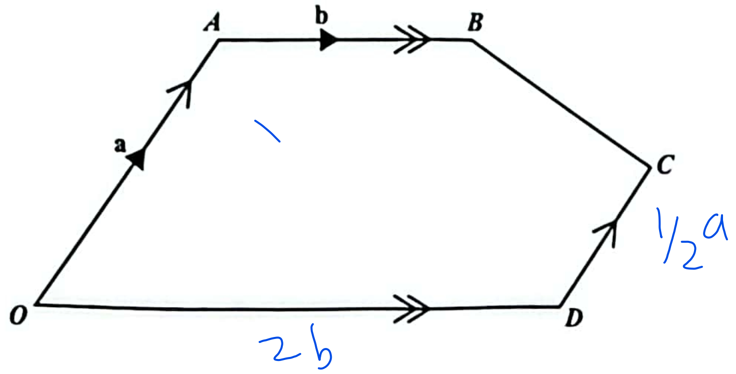
(d) In the pentagon $OABCD$, OA is parallel to DC and AB is parallel to OD.

$OD = 2AB$ and $OA = 2DC$. $\overrightarrow{OA} = \mathbf{a}$ and $\overrightarrow{AB} = \mathbf{b}$.



Find, in terms of **a** and **b**, in its simplest form,

(i) $\overrightarrow{AD}$ $= -a + 2b$

$2b - a$

(1 mark)

(ii) $\overrightarrow{BC}$. $-b - a + 2b + \frac{1}{2}a$

$\Rightarrow b - \frac{1}{2}a$

(2 marks)

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(iii) State the conclusion about $|\overrightarrow{AD}|$ and $|\overrightarrow{BC}|$ that can be drawn from your responses in (i) and (ii).

The path from B to C is longer than that of the path of A to D.
Hence $|BC| > |AD|$.

(1 mark)

Total 12 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.