

Name:	Class:	Class Register Number:
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中正中学

CHUNG CHENG HIGH SCHOOL (MAIN)

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**PRELIMINARY EXAMINATION 2026
SECONDARY 4 (MARKING SCHEME)**

MATHEMATICS

4052/02

Paper 2

Tuesday 18 August 2026

2 hours 15 minutes

Candidates answer on the Question Paper

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page.
 Write in dark blue or black pen.
 You may use an HB pencil for any diagrams or graphs.
 Do not use paper clips, glue or correction fluid.

Answer **all** questions.
 The number of marks is given in brackets [] at the end of each question or part question.

If working is needed for any question it must be shown with the answer. Omission of essential working will result in loss of marks. The total number of marks for this paper is 90.

The use of an approved scientific calculator is expected, where appropriate. If the degree of accuracy is not specified in the question, and if the answer is not exact, give the answer to three significant figures. Give answers in degrees to one decimal place.
 For π , use either your calculator value or 3.142.

For Examiner's Use	
Question Number	Marks Obtained
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total Marks	

This document consists of **21** printed pages and **1** blank page.

Mathematical Formulae

Compound interest

$$\text{Total amount} = P \left(1 + \frac{r}{100} \right)^n$$

Mensuration

$$\text{Curved surface area of a cone} = \pi r l$$

$$\text{Surface area of a sphere} = 4 \pi r^2$$

$$\text{Volume of a cone} = \frac{1}{3} \pi r^2 h$$

$$\text{Volume of a sphere} = \frac{4}{3} \pi r^3$$

$$\text{Area of triangle } ABC = \frac{1}{2} a b \sin C$$

$$\text{Arc length} = r \theta, \text{ where } \theta \text{ is in radian}$$

$$\text{Sector area} = \frac{1}{2} r^2 \theta, \text{ where } \theta \text{ is in radian}$$

Trigonometry

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a^2 = b^2 + c^2 - 2 b c \cos A$$

Statistics

$$\text{Mean} = \frac{\Sigma fx}{\Sigma f}$$

$$\text{Standard deviation} = \sqrt{\frac{\Sigma fx^2}{\Sigma f} - \left(\frac{\Sigma fx}{\Sigma f} \right)^2}$$

TURN OVER FOR QUESTION 1

1 (a) It is given that $y = \frac{6}{a} - \frac{a}{x}$.

(i) Express x in terms of a and y .

$$y = \frac{6}{a} - \frac{a}{x}$$

$$\frac{a}{x} = \frac{6}{a} - y \text{ ----- B1}$$

$$\frac{a}{x} = \frac{6 - ay}{a}$$

$$x = \frac{a^2}{6 - ay} \text{ ----- B1}$$

Answer $x = \dots\dots\dots$ [2]

(ii) Given that $x : y : a = 1 : 2 : 3$, find the value of y .

$$y = 2x \text{ and } a = 3x$$

$$2x = \frac{6}{3x} - \frac{3x}{x} \text{ ----- M1 (Apply ratio to simplify eq. in one unknown)}$$

$$2x = \frac{2}{x} - 3$$

$$2x^2 = 2 - 3x$$

$$2x^2 + 3x - 2 = 0 \text{ ----- M1 (Simplify into a quadratic equation)}$$

$$(2x - 1)(x + 2) = 0$$

$$x = \frac{1}{2} \text{ or } x = -2 \text{ (rej.)}$$

$$y = 2\left(\frac{1}{2}\right) = 1 \text{ ----- A1}$$

Answer $y = \dots\dots\dots$ [3]

- (b) Solve the equation $x^2 + 10x - 7 = 0$ by **completing the square**.

Give your solutions correct to 1 decimal place.

$$x^2 + 10x - 7 = 0$$

$$(x+5)^2 - 25 - 7 = 0 \text{ ----- B1 for } (x+5)^2$$

$$(x+5)^2 = 32$$

$$x+5 = \pm\sqrt{32} \text{ ----- M1 (applying square root)}$$

$$x = -\sqrt{32} - 5 \text{ or } \sqrt{32} - 5$$

$$= -10.7 \text{ (1 d.p)} \text{ or } 0.7 \text{ (1 d.p)} \quad \text{A1, A1}$$

Answer $x = \dots\dots\dots$ or $\dots\dots\dots$ [4]

- 2 (a) Mei invests a sum of money at a compound interest of $r\%$ per annum. At the end of 4 years, the value of her investment has increased by 25%.

Find the value of r .

$$A = P \left(1 + \frac{r}{100} \right)^n$$

$$\frac{A}{P} = 1.25 \text{ and } n = 4 \text{ ----- B1 (recognise that } \frac{A}{P} = 1.25)$$

$$1.25 = \left(1 + \frac{r}{100} \right)^4$$

$$1 + \frac{r}{100} = \sqrt[4]{1.25} \text{ ----- M1 (applying 4th root)}$$

$$r = 5.74 \text{ (3 s.f.) ----- A1}$$

Answer $r = \dots\dots\dots$ [3]

- (b) John borrows \$15 000 from a Singapore bank for 3 years to pay for an overseas course in France that costs €9,800.

The exchange rate between Singapore dollars and euros is \$1 = €0.625.

The bank charges simple interest at a rate of 5% per annum.

- (i) Show with clear workings whether the amount borrowed is sufficient to pay for the course fee.

Answer [1]

$$\begin{aligned} \text{Amount borrowed} &= €(15000 \times 0.625) \\ &= €9375 \end{aligned}$$

Since the amount borrowed is less than €9800, it is insufficient to pay for the course fee.

- (ii) Calculate the total amount John has to repay the Singapore bank after 3 years.

$$\begin{aligned} \text{Total interest} &= \$ \left(15000 \times \frac{5}{100} \times 3 \right) \quad \text{M1 (allow for 'copy' error in 15000)} \\ &= \$2250 \end{aligned}$$

$$\begin{aligned} \text{Total amount} &= \$ (2250 + 15000) \\ &= \$17250 \quad \text{A1} \end{aligned}$$

Answer \$ $\dots\dots\dots$ [2]

(c) In a number sequence, the sum of the first n terms is given by $S_n = n^2 + 3n$.

(i) Find the sum of the 15th to the 30th term.

$$\begin{aligned}\text{Sum} &= S_{30} - S_{14} \\ &= [30^2 + 3(30)] - [14^2 + 3(14)] \\ &= 752 \quad \text{B1}\end{aligned}$$

Answer [1]

(ii) By finding S_{n-1} , show that all the terms in the number sequence are always even.

Answer [3]

$$\begin{aligned}S_{n-1} &= (n-1)^2 + 3(n-1) \quad \text{----- M1 (Simplifying)} \\ &= n^2 - 2n + 1 + 3n - 3 \\ &= n^2 + n - 2\end{aligned}$$

$$\begin{aligned}T_n &= S_n - S_{n-1} \\ &= (n^2 + 3n) - (n^2 + n - 2) \quad \text{----- M1 (Recognise } T_n \text{)} \\ &= 2n + 2 \\ &= 2(n+1)\end{aligned}$$

(has a factor 2)

Since $n+1$ is an integer and T_n is a multiple of 2, therefore all the terms in the number sequence are always even. [A1]

(iii) $T_3, T_6, T_9, \dots$ is a new sequence formed by taking every 3rd term of the original sequence.

Find an expression, in terms of m to represent the m^{th} term of the new sequence.

$$\text{From (ii), } T_n = 2n + 2$$

The m^{th} term of the new sequence is the $(3m)^{\text{th}}$ term of the original sequence.

$$\begin{aligned}m^{\text{th}} \text{ term} &= 2(3m) + 2 \\ &= 6m + 2 \quad \text{[B1, B1]}\end{aligned}$$

Answer [2]

- 3 A weather station recorded the temperature of a city, T in degrees Celsius, at various times between 8.30 p.m. on 15 July and 3.30 a.m. on 16 July.

Let t be the time, in hours, measured relative to midnight at the start of 16 July.

Some of the recorded temperatures are shown in the table below.

t	-3.5	-3	-2	-1	0	1	2	2.5	3.5
T	-3.9	0	3.75	3.6	1.35	-1.2	-2.25	-1.65	2.93

For example: $t = -3$ correspond to 9 p.m. on 15 July.

The temperature can be modelled by the equation $T = k(t+3)(t-p)(t-q)$ where k , p and q are constants.

- (a) On the grid opposite, plot the points given in the table and join them with a smooth curve. [3]

- (b) Using your graph, estimate the values of p and q .

Answer $p = \dots 0.5 \dots \text{B1} (\pm 0.1) \dots$

$q = \dots 3 \dots \text{B1} (\pm 0.1) \dots$

[2]

- (c) By drawing a tangent, find the gradient of the curve at $t = -2$ and state the units in your answer.

$$\text{Gradient} = \frac{5-2}{-1.3+3}$$

$$= 1.76 \text{ } ^\circ\text{C/h (3 s.f.)} \text{ ----- A1, B1 (for units)}$$

$$(1.45 \text{ to } 1.85)$$

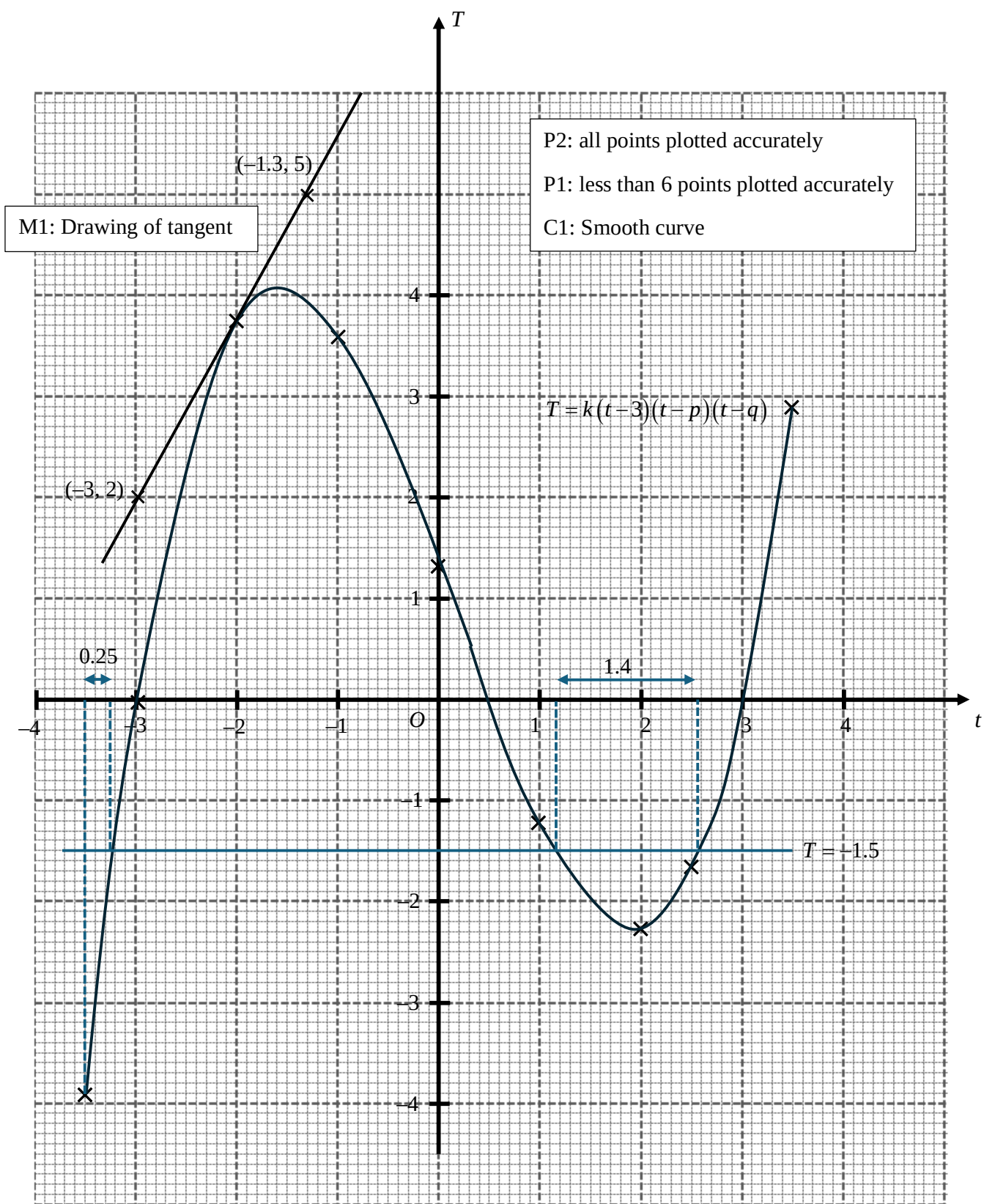
Answer [3]

- (d) A warning is issued whenever $T \leq -1.5$. Using your graph, estimate the duration in which the warning would have been active.

$$\text{Duration} = 1.4 + 0.25 = 1.65 \text{ hours B1}$$

(± 0.1 dependent on working lines)

Answer hours [1]



- 4 A fruit wholesaler collects information about the masses of pears supplied by Farm A and Farm B.

The stem-and-leaf diagram shows the masses of a sample of 20 pears from Farm A.

15	5	8							
16	0	2	3	5	7	9			
17	0	1	2	4	4	5	6	8	
18	0	2	3	5					

Key: 15 | 8 means 158 grams

Find

- (a) the median,

The median is the mean of the 10th and 11th values.

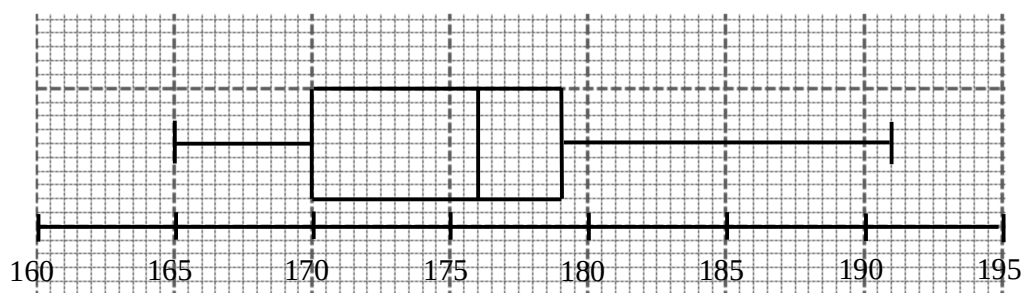
$$\frac{171+172}{2} = 171.5 \quad \text{B1} \quad \text{Answer} \dots\dots\dots \text{grams [1]}$$

- (b) the interquartile range.

$$\left. \begin{array}{l} Q_1 = \frac{163+165}{2} = 164 \\ Q_3 = \frac{176+178}{2} = 177 \end{array} \right\} \text{B1 (either one)} \quad \text{Answer} \dots\dots\dots \text{grams [2]}$$

$$\text{Interquartile range} = 177 - 164 = 13 \quad \text{[B1]}$$

The box-and-whisker diagram shows the masses of 20 pears sampled from Farm B.



- (c) The fruit wholesaler examines the box-and-whisker diagram and comments:
 “A higher proportion of Farm B's pears are heavier, since its right whisker is longer than its left whisker”.

Comment on whether the wholesaler’s comment is correct. [2]

Answer
 Comment is not correct + Identify the misconception (B1) and justifying why it's wrong using a specific statistical fact. (B1)

..... The longer right whisker only tells us that the heaviest 25% of the pears have a wider range of masses. [B1] The proportion of pear in the right whisker is equal to the
 of pears in the left whisker. [B1]

- (d) Recommend which farm the wholesaler should purchase from.

Explain and justify your choice with reference to appropriate statistical measures. [3]

Answer

Farm B has a higher median mass (176 g) compared to Farm A (171.5 g), indicating that

Farm B's pears are heavier. [B1] Farm B also has a smaller interquartile range (9g) than

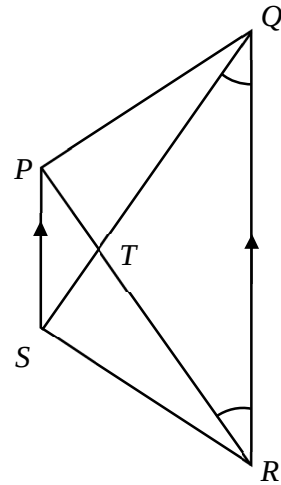
Farm A (13 g), indicating that the pears are more consistent in size. [B1]

The wholesaler should purchase from Farm B as the heavier pears are likely to command higher prices, and the greater consistency in size makes pricing and packaging more predictable. [B1]

What the justification mark is looking for:

Plausible real-world reason for why the statistical difference they identified actually matters to the wholesaler's decision, explain **why that number is desirable in context**.

- 5 (a) $PQRS$ is a trapezium where PS is parallel to QR .
 QS intersects PR at T .
 Angle $TQR = \text{angle } QRT$.



Show that triangles PQT and SRT are congruent.

Answer

[5]

$\angle TPS = \angle QRT$ and $\angle TSP = \angle TQR$ (alternate $\angle$ s, $PS \parallel QR$)

Given that $\angle TQR = \angle QRT$, thus $\angle TPS = \angle TSP$.

Therefore, triangle PTS is isosceles, $TP = TS$.

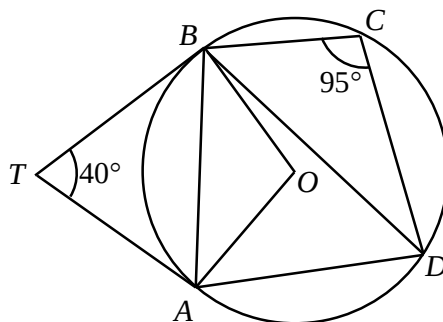
Since $\angle TQR = \angle QRT$, triangle QTR is isosceles, thus $TQ = TR$.

$\angle PTQ = \angle STR$ (vertically opposite $\angle$ s)

By SAS congruency test, triangles PQT and SRT are congruent.

B1: Identify 2 pairs of equal alternate angles using parallel lines
 B1: Show that triangle QTR is isosceles and hence $TQ = TR$
 B1: Show that triangle PTS is isosceles and hence $TP = TS$
 B1: Identify the pair of vertically opposite angles at T
 B1: Conclude SAS congruency

(b)



In the diagram, A , B , C and D are points on a circle, centre O .

The tangents at A and B meet at T .

Angle $ATB = 40^\circ$ and angle $BCD = 95^\circ$.

Find, giving reasons for each step of your working,

(i) angle BOA ,

$$\angle TBO = 90^\circ \text{ and } \angle TAO = 90^\circ \text{ (tangent } \perp \text{ radius) ----- B1}$$

$$\begin{aligned} \angle BOA &= 360^\circ - 90^\circ - 90^\circ - 40^\circ \text{ (sum of } \angle\text{s in quadrilateral)} \\ &= 140^\circ \text{ ----- B1} \end{aligned}$$

Answer[2]

(ii) angle ACB ,

$$\begin{aligned} \angle BDA &= \frac{140^\circ}{2} \text{ (} \angle \text{ at centre} = 2 \times \angle \text{ at circumference) ----- B1} \\ &= 70^\circ \end{aligned}$$

$$\angle ACD = 70^\circ \text{ (} \angle\text{s in the same segment) ----- B1}$$

Answer[2]

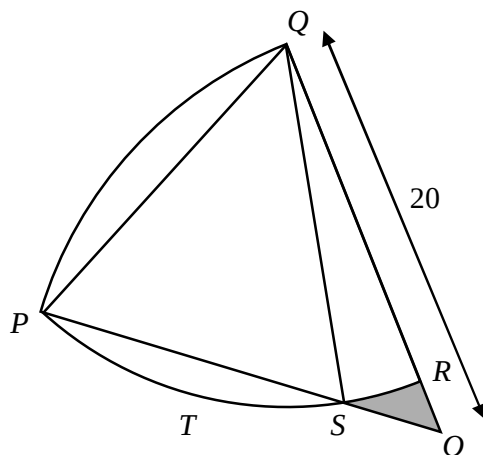
(iii) angle OAD .

$$\begin{aligned} \angle OAB &= \frac{180^\circ - 140^\circ}{2} \text{ (base } \angle\text{s of isosceles } \Delta, OA = OB) \text{ ---- B1} \\ &= 20^\circ \end{aligned}$$

$$\begin{aligned} \angle BAD &= 180^\circ - 95^\circ \text{ (} \angle\text{s in opposite segment) ----- B1} \\ &= 85^\circ \end{aligned}$$

$$\begin{aligned} \angle OAD &= 85^\circ - 20^\circ \\ &= 65^\circ \text{ ----- B1} \end{aligned}$$

Answer[3]



In the diagram, OPQ is a sector of a circle, centre O and radius 20 cm.

$PTS R$ is an arc of another circle, centre Q .

The length of arc PQ is 14.8 cm.

- (a) Show that angle $POQ = 0.74$ radians. [1]

Answer

$$\begin{aligned}\angle POQ &= \frac{14.8}{20} \\ &= 0.74 \text{ (shown)}\end{aligned}$$

- (b) Show that $QS = 14.5$ cm. [2]

Answer

Let M be the midpoint of PQ .

$$\sin \angle OQM = \frac{QM}{20} \quad \text{----- M1}$$

$$\begin{aligned}QM &= 20 \times \sin 0.37 \\ &= 7.2323...\end{aligned}$$

$$QP = 2 \times 7.2323...$$

$$= 14.4646...$$

$$QS = QP \quad \text{----- A1 (with 14.4546...)}$$

$$= 14.5 \text{ cm (shown)}$$

- (c) Find angle SQR .

$$\text{Since } OP = OQ, \angle QPS = \frac{\pi - 0.74}{2} \quad \text{----- M1}$$

$$= 1.200796...$$

$$\text{Since } QP = QS, \angle QSP = \angle QPS \quad \text{----- M1}$$

$$= 1.200796...$$

$$\angle SQR = 1.200796... - 0.74 \text{ (exterior } \angle \text{ of triangle)}$$

$$= 0.460796...$$

$$= 0.461 \text{ (3 s.f.)} \quad \text{----- A1}$$

Answer radians [3]

(d) Find the area of the shaded region.

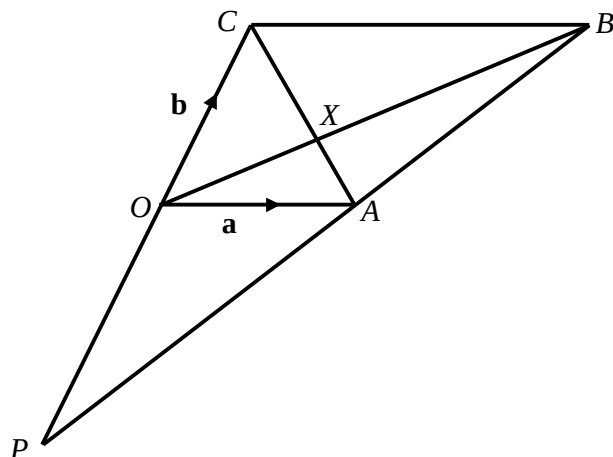
$$\begin{aligned}\text{Area of sector } QSR &= \frac{1}{2}(14.4646\dots)^2 (0.460796\dots) \text{ ----- M1} \\ &= 48.20494\dots \text{ cm}^2\end{aligned}$$

$$\begin{aligned}\text{Area of triangle } SQO &= \frac{1}{2}(14.4646\dots)(20) \sin 0.460796\dots \text{ ----- M1} \\ &= 64.318467\dots \text{ cm}^2\end{aligned}$$

$$\begin{aligned}\text{Area of shaded region} &= 64.318467\dots - 48.20494\dots \\ &= 16.1 \text{ cm}^2 \text{ (3 s.f) ----- A1}\end{aligned}$$

Answer cm^2 [3]

- 7 In the diagram, $OABC$ is a quadrilateral where the diagonals OB and AC intersect at X .
 $\overrightarrow{OA} = \mathbf{a}$, $\overrightarrow{OC} = \mathbf{b}$ and $\overrightarrow{OB} = 2\mathbf{a} + \mathbf{b}$. The lines BA and CO are produced to meet at P .



- (a) Find $\overrightarrow{CB}$, giving your answer in terms of $\mathbf{a}$ and/or $\mathbf{b}$.

Hence, explain why $ABCO$ is a trapezium.

Answer

$$\begin{aligned}\overrightarrow{CB} &= \overrightarrow{CO} + \overrightarrow{OB} \\ &= -\mathbf{b} + (2\mathbf{a} + \mathbf{b}) \\ &= 2\mathbf{a} \text{ ----- B1}\end{aligned}$$

Since $\overrightarrow{CB} = 2\overrightarrow{OA}$, $CB \parallel OA$. ----- M1

Therefore, $ABCO$ has one pair of opposite side parallel, and this is a trapezium. A1

Answer $\overrightarrow{CB} = \dots\dots\dots$ [3]

- (b) Giving your answers in terms of $\mathbf{a}$ and/or $\mathbf{b}$, find

- (i) $\overrightarrow{OX}$.

$$\begin{aligned}\overrightarrow{OX} &= \frac{1}{3}\overrightarrow{OB} \\ &= \frac{1}{3}(2\mathbf{a} + \mathbf{b}) = \frac{2}{3}\mathbf{a} + \frac{1}{3}\mathbf{b} \text{ B1}\end{aligned}$$

Answer $\overrightarrow{OX} = \dots\dots\dots$ [1]

- (ii) $\overrightarrow{AB}$.

$$\begin{aligned}\overrightarrow{AB} &= \overrightarrow{AO} + \overrightarrow{OB} \\ &= -\mathbf{a} + (2\mathbf{a} + \mathbf{b}) = \mathbf{a} + \mathbf{b} \text{ B1}\end{aligned}$$

Answer $\overrightarrow{AB} = \dots\dots\dots$ [1]

- (c) Find the ratio of area of triangle OAX : area of triangle OAC .

$$\frac{\text{area of } \triangle OAX}{\text{area of } \triangle OAC} = \frac{AX}{AC} = \frac{1}{1+2} = \frac{1}{3} \quad \text{B1}$$

The ratio is 1 : 3.

Answer [1]

- (d) Using vector method, find $\overrightarrow{OP}$ and show that O is the midpoint of PC . [4]

Answer

Let $\overrightarrow{AP} = k\overrightarrow{AB}$ where k is a constant ----- M1

$$\overrightarrow{OP} = \overrightarrow{OA} + \overrightarrow{AP}$$

$$= \mathbf{a} + k(\mathbf{a} + \mathbf{b}) \quad \text{----- M1}$$

$$= (1+k)\mathbf{a} + k\mathbf{b}$$

Since P , O and C are collinear, $\overrightarrow{OP}$ must be a scalar multiple of $\mathbf{b}$.

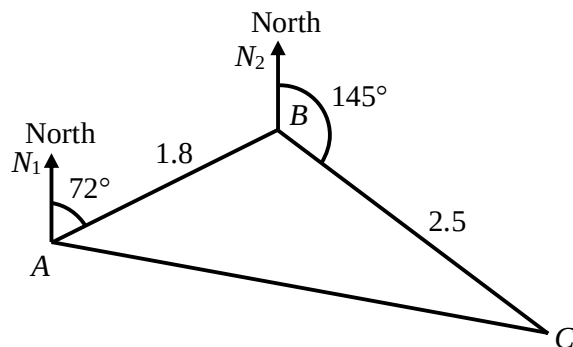
$$1+k=0 \quad \text{----- M1}$$

$$k = -1$$

$$\text{Thus } \overrightarrow{OP} = -\overrightarrow{OC}. \quad \text{----- A1}$$

Hence, O is the midpoint of PC .

- 8 An orienteering course has three checkpoints, A, B and C, on level ground. The bearing of B from A is 072° and the bearing of C from B is 145° . $AB = 1.8\text{ km}$ and $BC = 2.5\text{ km}$.



- (a) Find the distance AC.

$$\angle ABN_2 = 180^\circ - 72^\circ$$

$$= 108^\circ$$

$$\angle ABC = 360^\circ - 145^\circ - 108^\circ \text{ ----- M1}$$

$$= 107^\circ$$

$$AC^2 = 1.8^2 + 2.5^2 - 2(1.8)(2.5)\cos 107^\circ \text{ ----- M1}$$

$$= 12.12134...$$

$$AC = \sqrt{12.12134...} \text{ (-ve value rej.)}$$

$$= 3.48147...$$

$$= 3.48 \text{ km (3 s.f.) ----- A1}$$

Answer km [3]

- (b) Find the bearing of C from A.

$$\frac{\sin \angle BAC}{2.5} = \frac{\sin 107^\circ}{3.48157...} \text{ ----- M1}$$

$$\sin \angle BAC = 0.6866907...$$

$$\angle BAC = \sin^{-1} 0.6866907...$$

$$= 43.36872...\circ$$

$$\text{Bearing} = 72^\circ + 43.36872...\circ$$

$$= 115.4^\circ \text{ (1 d.p.) ----- A1}$$

Answer [2]

- (c) Find the shortest distance from B to the AC .

Let D be the foot of the perpendicular from B to AC .

The shortest distance is BD .

$$\sin 43.36872\dots^\circ = \frac{BD}{1.8} \quad \text{-----} \quad \text{M1}$$

$$\begin{aligned} BD &= 1.8 \times \sin 43.36872\dots^\circ \\ &= 1.24 \text{ km (3 s.f)} \quad \text{-----} \quad \text{A1} \end{aligned}$$

Answer[2]

- (d) A boy walks along the path AC . He stops at a point that is closest to B and releases a signal flare that rises vertically.

Find the angle of elevation of the signal flare from point A when it reaches a height of 250 m.

Let D be the point on AC closest to B .

$$\cos 43.3687\dots^\circ = \frac{AD}{1.8} \quad \text{-----} \quad \text{M1}$$

$$\begin{aligned} AD &= 1.8 \times \cos 43.3687\dots^\circ \\ &= 1.308509\dots \text{ km} \end{aligned}$$

The height of the flare is 0.25 km.

Let the angle of elevation from A be θ .

$$\tan \theta = \frac{0.25}{1.308509\dots} \quad \text{-----} \quad \text{M1}$$

$$\begin{aligned} \theta &= \tan^{-1} \frac{0.25}{1.308509\dots} \\ &= 10.8^\circ \text{ (1 d.p)} \quad \text{-----} \quad \text{A1} \end{aligned}$$

Answer [3]

- 9 A coastal city has an existing sea dike to protect its low-lying land from rising sea levels. The dike has a uniform trapezoidal cross-section, $ABCD$, as shown in **Diagram (a)**. Its crest, BC , is 8 m wide and its base, AD , is 38 m wide. The crest is 6 m above the current mean sea level. The seaward face rises over a horizontal distance of 18 m from A to F . The dike extends 10 km along the coast and has the same cross-section throughout its length.

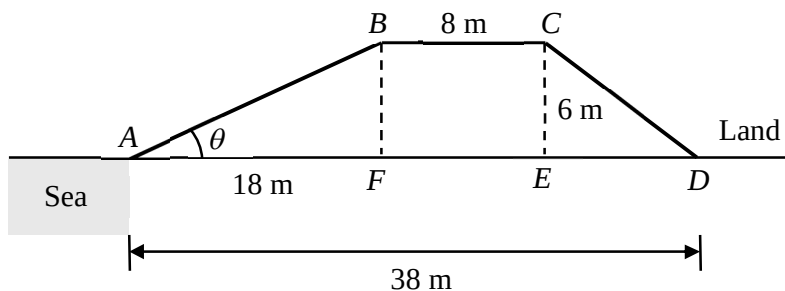


Diagram (a)

- (a) Find the angle, θ , that the seaward face of the dike makes with the horizontal.

$$\tan \theta = \frac{6}{18}$$

$$\theta = \tan^{-1}\left(\frac{1}{3}\right) = 18.4349\dots^\circ = 18.4^\circ \text{ (1 d.p.)} \quad \text{B1}$$

Answer [1]

- (b) Find the volume of fill used to build the 10 km dike, leaving your answer in cubic metres.

$$\text{Cross-sectional area of trapezium} = \frac{1}{2}(8 + 38) \times 6 \quad \text{----- M1}$$

$$= 138 \text{ m}^2$$

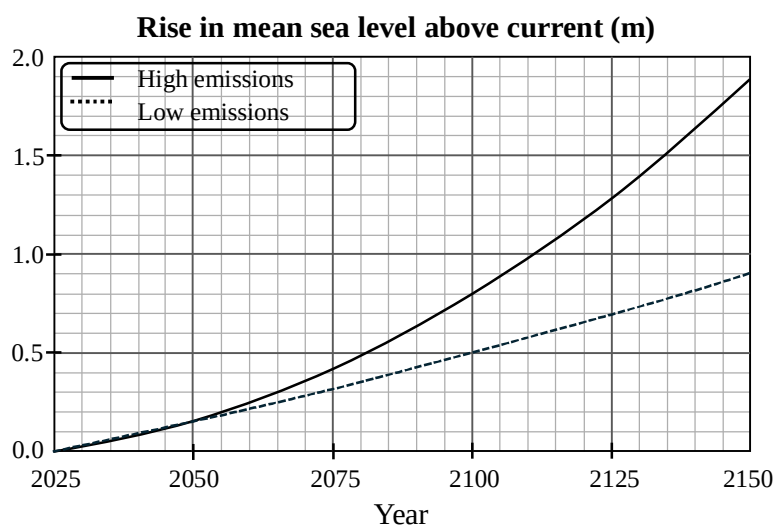
$$10 \text{ km} = 10\,000 \text{ m}$$

$$\text{Volume} = 138 \times 10\,000$$

$$= 1\,380\,000 \text{ m}^3 \quad \text{----- A1}$$

Answer m^3 [2]

The graph below shows the projected rise in mean sea level (above the current mean sea level) under two global emission scenarios.



For safety, engineers require the dike crest to remain at least 4.5 m above the projected mean sea level, to allow for high tides, storm surge and a safety margin. The width of the crest and gradients of the sloping faces remain unchanged as shown in **Diagram (b)**.

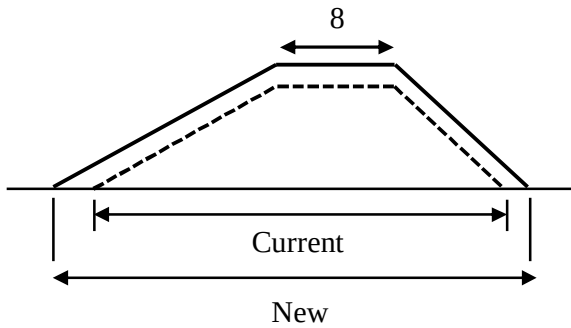


Diagram (b)

Cost information

- Fill (sand): \$25 per cubic metre.
- Sea-level rise causes erosion of the seaward face. Therefore, approximately 2000 m³ of sand is needed for renourishment in the first year, increasing steadily to 40000 m³ in 50 years.
- Design life of the dike: 50 years

You are an engineer preparing a budget proposal for the city council to protect the coast. The budget must include:

- the cost of additional fill required to raise the existing dike so that it meets the safety requirement in the year 2150 under the high-emissions scenario; and
 - the cost of maintaining the dike by replacing fill lost through erosion over the following 50 years.
- (c) Using the graph and the cost information provided, recommend a budget for the council to approve. Justify your recommended budget with clear workings.

Answer

[8]

From the graph, the projected rise in mean sea level in 2150 under high-emissions scenario is 1.9 m.	B1 (sea level)
Required height = $4.5 + 1.9 = 6.4$ m	M1 (new height)
New seaward horizontal distance = $18 \times \frac{6.4}{6} = 19.2$ m New landward horizontal distance = $12 \times \frac{6.4}{6} = 12.8$ m New base width = $19.2 + 8 + 12.8 = 40$ m	M1 (application of similarity or gradient)
New cross-sectional area = $\frac{1}{2}(40 + 8)(6.4) = 153.6$ m ² New volume = $153.6 \times 10000 = 1536000$ m ³ Additional volume = $1536000 - 1380000 = 156000$ m ³ Cost of raising dike = $156000 \times \$25 = \3900000	M1 (new cross-sectional area) M1 (cost of raising dike)
Estimated annual loss = $\frac{1}{2}(2000 + 40000) = 21000$ m ³ Total replacement volume over 50 years = $50 \times 21000 = 1050000$ m ³ Cost of maintenance = $1050000 \times \$25 = \26250000 Total cost = $\$3900000 + \$26250000 = \$30150000$ The recommended budget is \$30.2 million	M1 (estimate loss) M1 (cost of maintenance) A1