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Mathematics: applications and interpretation

Standard level

Paper 1

30 October 2023

Zone A afternoon | Zone B afternoon | Zone C afternoon

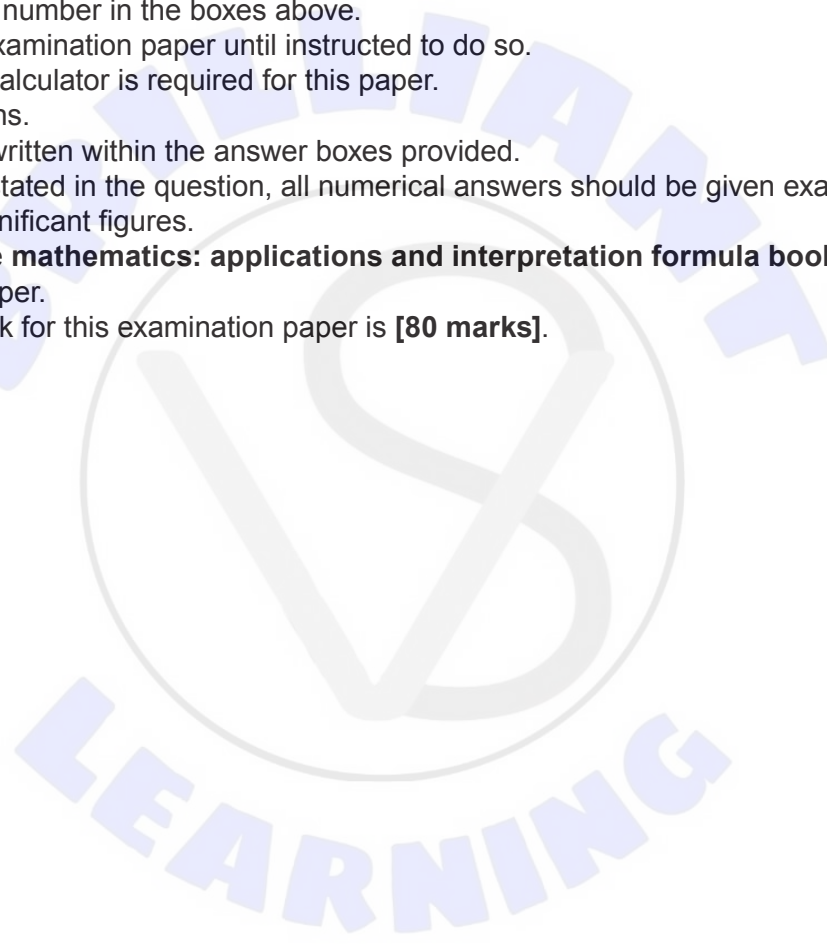
Candidate session number

1 hour 30 minutes

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Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- A graphic display calculator is required for this paper.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- Unless otherwise stated in the question, all numerical answers should be given exactly or correct to three significant figures.
- A clean copy of the **mathematics: applications and interpretation formula booklet** is required for this paper.
- The maximum mark for this examination paper is **[80 marks]**.



Answers must be written within the answer boxes provided. Full marks are not necessarily awarded for a correct answer with no working. Answers must be supported by working and/or explanations. Solutions found from a graphic display calculator should be supported by suitable working. For example, if graphs are used to find a solution, you should sketch these as part of your answer. Where an answer is incorrect, some marks may be given for a correct method, provided this is shown by written working. You are therefore advised to show all working.

1. [Maximum mark: 7]

Joel is a keen cyclist who keeps a record of his performance. The following table shows the time, in minutes, it takes him to ride one kilometre on hills with different gradients. The gradient of each hill is constant.

Gradient G (%)	0	4	10	15	20
Time T (min.)	2.11	5.39	10.56	13.20	18.58

- (a) (i) Find the equation of the regression line of T on G .
- (ii) Describe the correlation between T and G with reference to the value of r , the Pearson's product-moment correlation coefficient. [4]

On Saturday, Joel intends to ride a hill with a gradient of 17%.

- (b) Estimate the time it will take Joel to ride one kilometre up the hill. [2]

This morning, Joel rode one kilometre up a hill, and it took 22 minutes.

- (c) Explain why it would be inappropriate to use the equation found in part (a) to estimate the gradient of this hill. [1]

(This question continues on the following page)



4. [Maximum mark: 8]

On the following Voronoi diagram, the coordinates of three farmhouses are $A(0, 3)$, $B(8, 3)$ and $C(8, 13)$, where distances are measured in kilometres. Each farmhouse owns the land that is closest to it, and their boundaries are defined by the dotted lines on **Diagram 1**.

Diagram 1

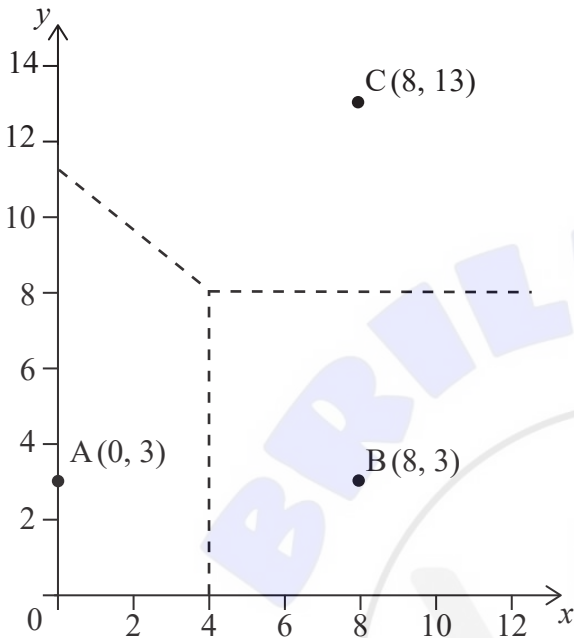
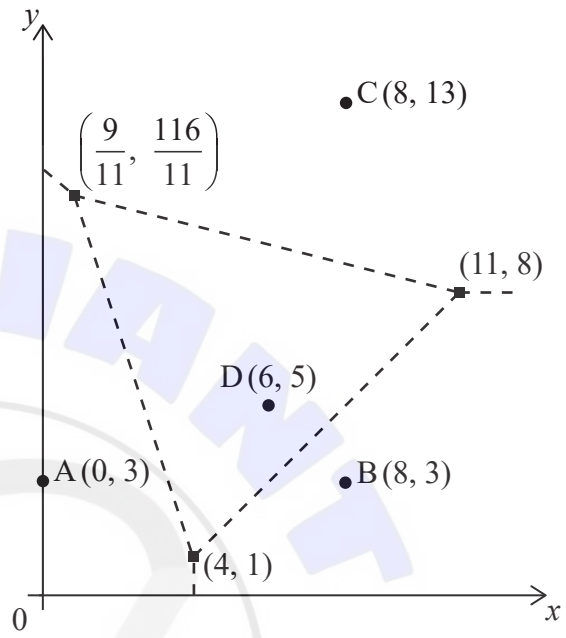


Diagram 2



To provide water to the farms it is decided to construct a well at the point where the boundaries meet on **Diagram 1**.

- (a) Write down the coordinates of this point. [1]
- (b) Find the equation of the perpendicular bisector of $[AC]$. [3]

An additional farmhouse $D(6, 5)$ is built on the land. The Voronoi diagram has been redrawn to show the new boundaries. The coordinates of the vertices of these boundaries are indicated on **Diagram 2**.

A wind turbine is to be built at one of the vertices.

- (c) The wind turbine should be as far from the nearest farmhouses as possible.
 - (i) By calculating appropriate distances, find the location of the wind turbine.
 - (ii) Hence, write down the distance of the wind turbine to the nearest farmhouse. [4]

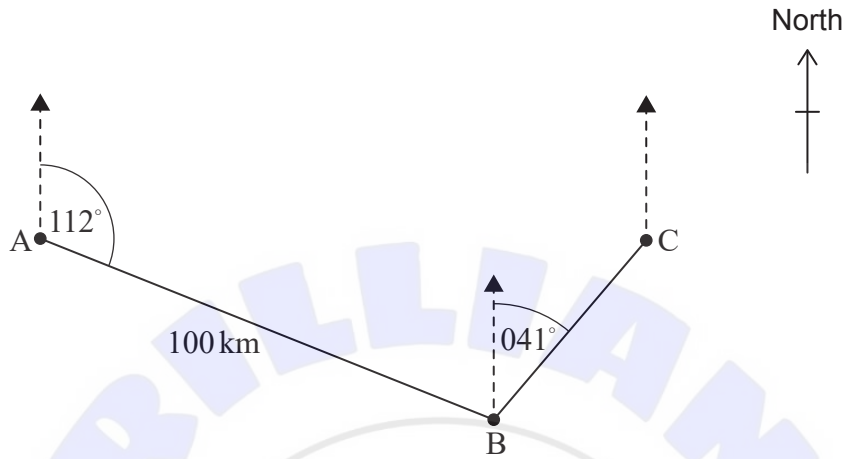
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5. [Maximum mark: 6]

Jason sails his boat from point A for a distance of 100 km, on a bearing of 112° , to arrive at point B. He then sails on a bearing of 041° to point C. Jason's journey is shown in the diagram.

diagram not to scale



(a) Find $\hat{A}BC$. [2]

Point C is directly east of point A.

(b) Calculate the distance that Jason sails to return directly from point C to point A. [4]

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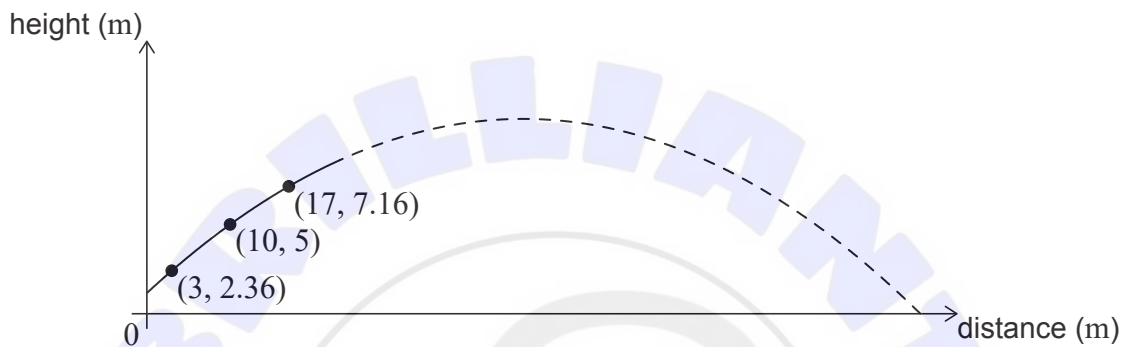
7. [Maximum mark: 9]

A sports player on a horizontal athletic field hits a ball. The height of the ball above the field, in metres, after it is hit can be modelled using a quadratic function of the form $f(x) = ax^2 + bx + c$, where x represents the horizontal distance, in metres, that the ball has travelled from the player.

A specialized camera tracks the initial path of the ball after it is hit by the player. The camera records that the ball travels through the three points (3, 2.36), (10, 5) and (17, 7.16), as shown in **Diagram 1**.

diagram not to scale

Diagram 1

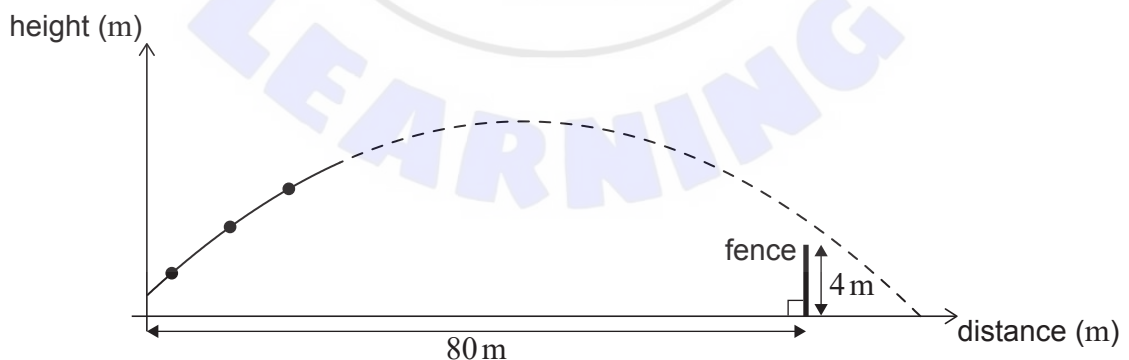


- (a) Use the coordinates (3, 2.36) to write down an equation in terms of a , b , and c . [1]
- (b) Use your answer to part (a) and two similar equations to find the equation of the quadratic model for the height of the ball. [3]

A 4-metre-high fence is 80 metres from where the player hit the ball, as shown in **Diagram 2**.

diagram not to scale

Diagram 2



- (c) Show that the model predicts that the ball will go over the fence. [3]
- (d) Find the horizontal distance that the ball will travel, from the player until it first hits the ground, according to this model. [2]

(This question continues on the following page)



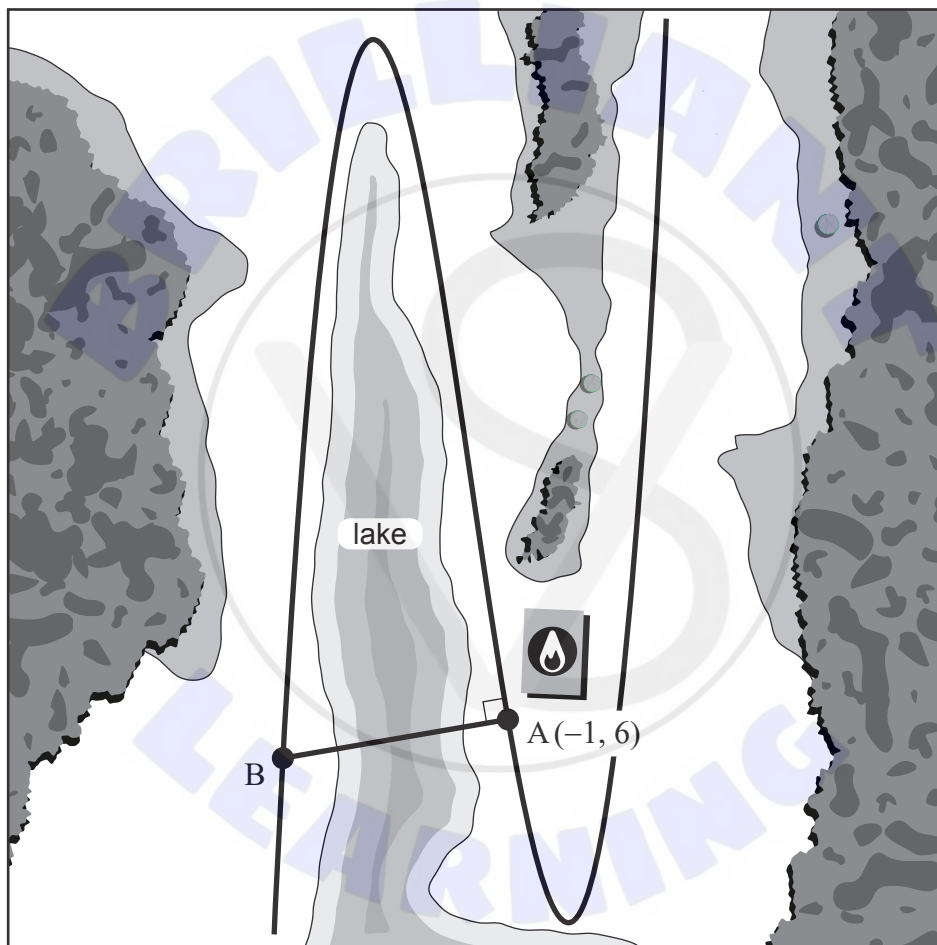
8. [Maximum mark: 7]

The diagram shows a map containing a long, winding road passing a lake. The shape of the road can be modelled by the function $r(x) = (x + 1)^3 + 2x^2 - 4x$. All distances in the map are in kilometres.

The local fire station is located at point A, which has coordinates $(-1, 6)$.

To save time during emergencies, the local community is planning the construction of a bridge over the lake. The bridge will be built such that it is normal to the road at point A and will connect the fire station to point B.

diagram not to scale



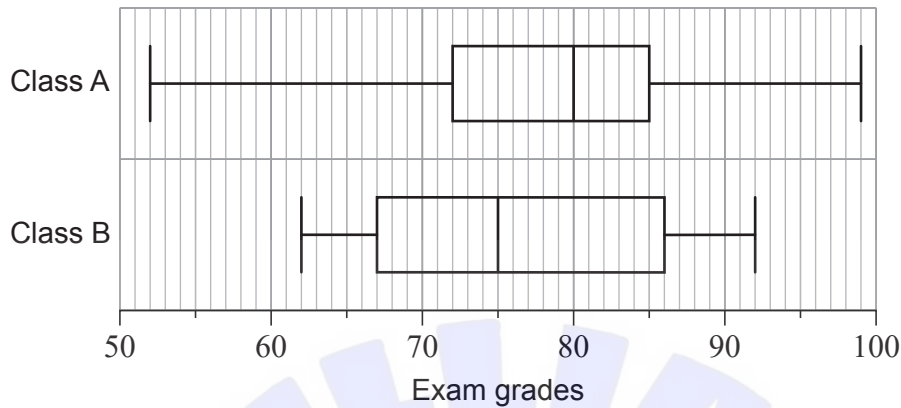
- (a) Using your graphic display calculator, find the value of $r'(-1)$. [2]
- (b) Find the equation of the line normal to $r(x)$ at point A, which can be used to model the new bridge. [2]
- (c) Hence, determine the length of the new bridge. [3]

(This question continues on the following page)



9. [Maximum mark: 8]

Mr Kelly is a history teacher. After grading his final exams, he creates the following box and whisker diagram to compare the grades of his two classes.



(a) Identify which **two** of the following statements **must** be true according to the box and whisker diagram. Indicate your choices by placing tick marks in the second column of the following table.

[2]

Statement	True (✓)
A higher percentage of students in Class B received a grade less than 70 on the exam, than in Class A.	
The data for Class B is normally distributed.	
More students in Class A received a grade greater than 90 on the exam than in Class B.	
The interquartile range for Class A is less than the interquartile range for Class B.	

At the end of the year, Mr Kelly surveyed a random sample of students from each of his two large classes to determine how satisfied they were with his teaching.

Each student independently selected a value from 1 to 10, with 1 meaning that they were not satisfied at all and 10 meaning that they were very satisfied.

His collected data from the student surveys is shown.

Class A	6	9	8	10	1	9	10	9	8	4
Class B	7	5	3	4	3	8	6	7		

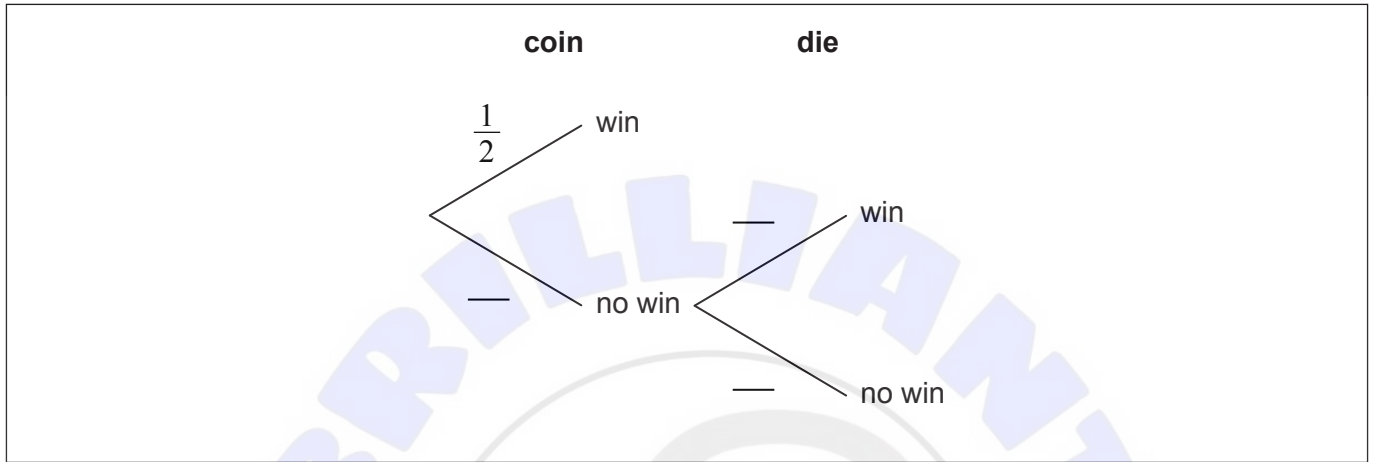
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10. [Maximum mark: 7]

Michèle is playing a game. In the game, she must first flip a fair coin which will result in the coin landing on heads or tails. If the coin lands on heads, then she wins a prize. If it lands on tails, then she has another chance but this time she must roll a fair six-sided die and get a five or six in order to win a prize.

- (a) Complete the tree diagram by writing in the three missing probabilities. [2]



- (b) Find the probability that Michèle does **not** win a prize. [2]
- (c) Given that Michèle won a prize, find the probability that the coin landed on heads. [3]

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12. [Maximum mark: 6]

Thurston believes that more popular musical artists sell more albums.

He begins to investigate this belief by randomly selecting eight musical artists and collecting data on the number of followers each of the artists has on a particular social media platform. He then collects data on the number of albums each artist sold in the first week after releasing an album. His data is shown in **Table 1**.

Table 1

	Artist 1	Artist 2	Artist 3	Artist 4	Artist 5	Artist 6	Artist 7	Artist 8
Number of social media followers (in thousands)	11 500	12 400	1300	2300	674	49 500	315	94 400
Number of albums sold in first week (in thousands)	123	62.4	17.4	94.9	52.5	27	21.6	595.5

Thurston decides to calculate the Spearman's rank correlation coefficient.

(a) Complete the table of ranks shown in **Table 2**.

[1]

Table 2

	Artist 1	Artist 2	Artist 3	Artist 4	Artist 5	Artist 6	Artist 7	Artist 8
Rank – social media followers	4	3	6	5	7	2	8	1
Rank – albums sold in first week								1

(This question continues on the following page)





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References:

2. Nina Aldin Thune. https://en.wikipedia.org/wiki/Great_Pyramid_of_Giza#/media/File:Kheops-Pyramid.jpg. Licensed under CC BY 2.5 <https://creativecommons.org/licenses/by/2.5/#>. Image adapted.

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