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**Mathematics: applications and interpretation**  
**Standard level**  
**Paper 1**

8 May 2023

**Zone A** afternoon | **Zone B** morning | **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: 6]

The decathlon is a competition where athletes compete in ten events. Two of those events are long jump and high jump. In both events, a greater distance means a better ranking.

The table shows results for these two events at the World Championships.

Athlete's Country	Event		Rank	
	Long Jump (m)	High Jump (m)	Long Jump Rank	High Jump Rank
Germany	7.64	2.11	1	
France	7.52	2.08	2	
Estonia	7.49	1.84	3	
Canada	7.44	2.02	4	
Netherlands	7.33	2.05	5	
Ukraine	7.28	2.02	6	
Algeria	7.22	1.90	7	
Austria	7.11	1.87	8	
Grenada	6.98	1.99	9	
Japan	6.64	1.96	10	

The Spearman's rank correlation coefficient is used to determine if there is a linear correlation between an athlete's ranking in long jump and their ranking in high jump.

- (a) Complete the table to show the athletes' rankings in high jump. [2]
- (b) Find the value of the Spearman's rank correlation coefficient  $r_s$ . [2]

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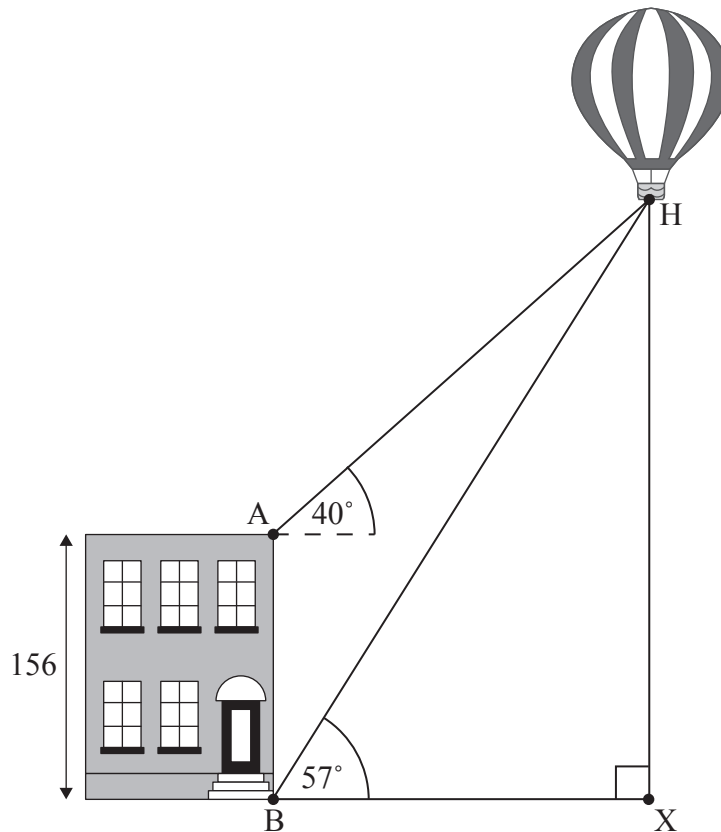


2. [Maximum mark: 6]

Point H on a hot-air balloon is sighted at the same time by two observers. One observer is at the top of a vertical building that is 156 metres tall. The other observer is at the base of the building.

The angle of elevation from point A (at the top of the building) to H is  $40^\circ$ , and the angle of elevation from point B (at the base of the building) to H is  $57^\circ$ . Point X is the ground directly below point H. This information is shown in the diagram.

diagram not to scale



- (a) Find the size of angle  $\widehat{AHB}$ . [2]
- (b) Calculate the distance from point B to point H. [3]

The hot-air balloon remains at a constant height as it moves further away from the building.

- (c) Describe, in words, the change in the angle of depression from point H to point B as the horizontal distance between the balloon and the building increases. [1]

(This question continues on the following page)







4. [Maximum mark: 6]

Carys believes that, on a memory retention test, the mean score of bilingual people ( $\mu_b$ ) will be higher than the mean score of monolingual people ( $\mu_m$ ). Carys gave a memory retention test to a random sample of students in her class. The results are shown in the two tables.

	Scores									
<b>Bilingual</b>	100	94	100	90	100	94	98	98	98	98

	Scores							
<b>Monolingual</b>	97	92	88	98	88	94	100	100

Carys performs a one-tailed  $t$ -test at a 5% level of significance. It is assumed that the scores are normally distributed and the samples have equal variances.

- (a) State the null and alternative hypotheses. [2]
- (b) Calculate the  $p$ -value for this test. [2]
- (c) State the conclusion of the test in the context of the question. Justify your answer. [2]

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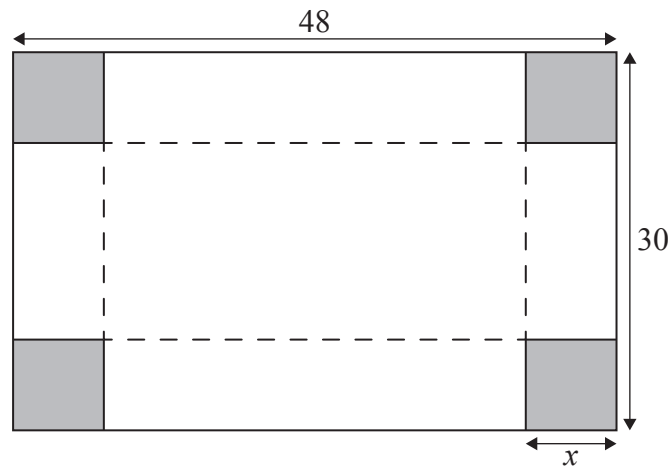


7. [Maximum mark: 6]

A rectangular box, with an open top, is to be constructed from a piece of cardboard that measures 48 cm by 30 cm.

Squares of equal size will be cut from the corners of the cardboard, as indicated by the shading in the diagram. The sides will then be folded along the dotted lines to form the box.

diagram not to scale



The volume of the box, in cubic centimetres, can be modelled by the function  $V(x) = (48 - 2x)(30 - 2x)(x)$ , for  $0 < x < k$ , where  $x$  is the length of the sides of the squares removed in centimetres.

- (a) Write down the maximum possible value of  $k$  in this context. [1]
- (b) Find the value of  $x$  that maximizes the volume of the box. [2]

A second piece of 48 cm by 30 cm cardboard is damaged and a strip 2 cm wide must be removed from all four sides. A box will then be constructed in a similar manner from the remaining cardboard.

- (c) Calculate the maximum possible volume of the box made from the second piece of cardboard. [3]

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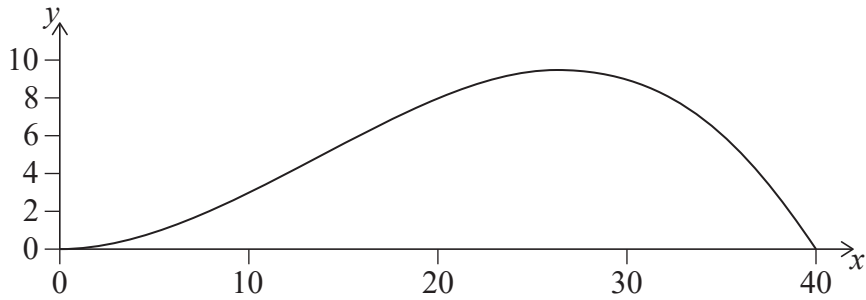






9. [Maximum mark: 8]

The cross section of a scale model of a hill is modelled by the following graph.



The heights of the model are measured at horizontal intervals and are given in the table.

<b>Horizontal distance, <math>x</math> cm</b>	0	10	20	30	40
<b>Vertical distance, <math>y</math> cm</b>	0	3	8	9	0

(a) Use the trapezoidal rule with  $h = 10$  to find an approximation for the cross-sectional area of the model. [2]

It is given that the equation of the curve is  $y = 0.04x^2 - 0.001x^3$ ,  $0 \leq x \leq 40$ .

(b) (i) Write down an integral to find the exact cross-sectional area.

(ii) Calculate the value of the cross-sectional area to two decimal places. [4]

(c) Find the percentage error in the area found using the trapezoidal rule. [2]

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10. [Maximum mark: 7]

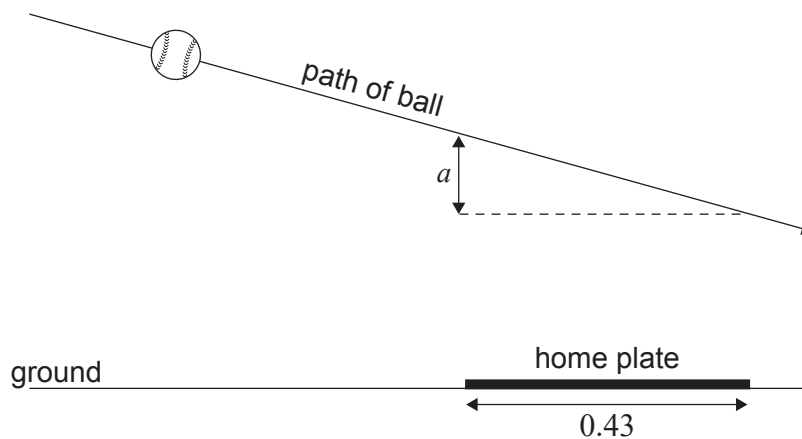
In a baseball game, Sakura is the batter standing beside home plate. The ball is thrown towards home plate along a path that can be modelled by the following function

$$y = -0.045x + 2.$$

In this model,  $x$  is the horizontal distance of the ball from the point the ball is thrown and  $y$  is the vertical height of the ball above the ground. Both measured in metres.

The outcome of the throw is called a strike if the height of the ball is between 0.53 m and 1.24 m at some point while it travels over home plate. The length of home plate is 0.43 m.

diagram not to scale



When the ball reaches the front of home plate, the height of the ball above the ground is 1.25 m. The height of the ball changes by  $a$  metres as the ball travels over the length of home plate.

- (a) (i) Find the value of  $a$ .
- (ii) Justify why this throw is a strike.

[4]

On the next throw, Sakura hits the ball towards a wall that is 5 metres high. The horizontal distance of the wall from the point where the ball was hit is 96 metres. The path of the ball after it is hit can be modelled by the function  $h(d)$ .

$$h(d) = -0.01d^2 + 1.04d + 0.66, \text{ for } h, d > 0$$

In this model,  $h$  is the height of the ball above the ground and  $d$  is the horizontal distance of the ball from the point where it was hit. Both  $h$  and  $d$  are measured in metres.

- (b) Determine whether the ball will go over the wall. Justify your answer.

[3]

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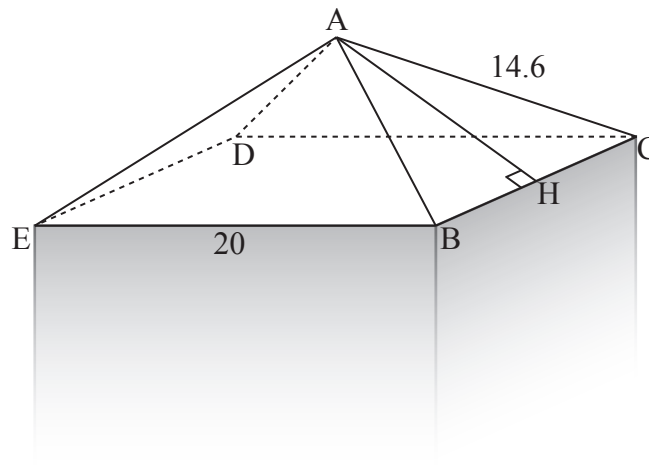


11. [Maximum mark: 7]

Vertical posts are to be placed around the outer edge of a children's park. Each post is formed from a cuboid with a right square-based pyramid on top.

The cuboid part of the post is machine-made such that its width, and hence the width of the pyramid, is exactly 20 cm. The length from the apex of the pyramid, A, to any corner of the base of the pyramid is 14.6 cm, **but** this is only accurate to the nearest tenth of a centimetre. The post is shown in the diagram.

diagram not to scale



- (a) Write down the upper bound and lower bound for the possible lengths of edge AC. [2]

Point H is the midpoint of BC.

- (b) Determine the upper bound and lower bound for AH, the slant height of the pyramid. [3]

For the post to be safe for children, the angle between the slant height and the base of the pyramid must be less than  $22^\circ$ .

- (c) Show that this post is safe for children. Justify your answer. [2]

(This question continues on the following page)









Please **do not** write on this page.

Answers written on this page  
will not be marked.



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