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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]**.



2. [Maximum mark: 6]

Angel has \$ 520 in his savings account. Angel considers investing the money for 5 years with a bank. The bank offers an annual interest rate of 1.2% compounded quarterly.

- (a) Calculate the amount of money Angel would have at the end of 5 years with the bank. Give your answer correct to two decimal places. [3]

Instead of investing the money, Angel decides to buy a phone that costs \$ 520. At the end of 5 years, the phone will have a value of \$ 30. It may be assumed that the depreciation rate per year is constant.

- (b) Calculate the annual depreciation rate of the phone. [3]

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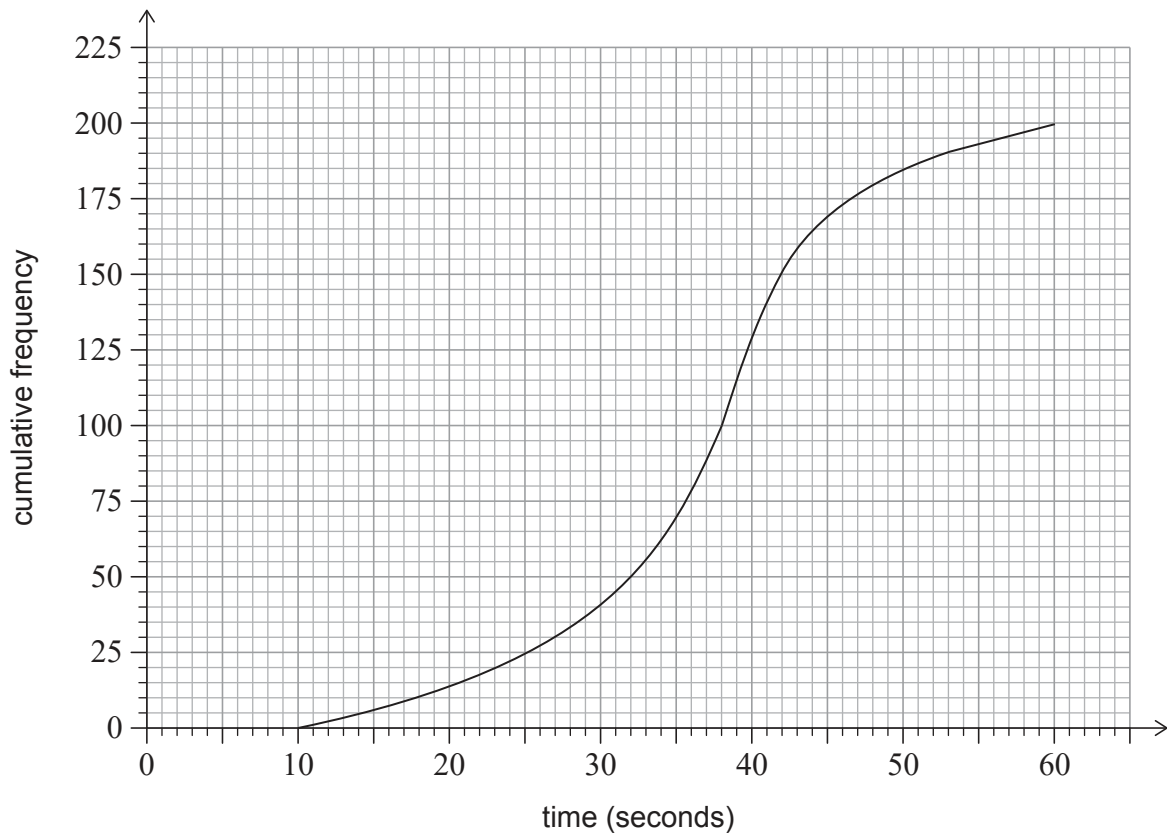


20EP03

Turn over

3. [Maximum mark: 7]

In a school, 200 students solved a problem in a mathematics competition. Their times to solve the problem were recorded and the following cumulative frequency graph was produced.



- (a) Use the graph to find
 - (i) the median time;
 - (ii) the lower quartile;
 - (iii) the upper quartile;
 - (iv) the interquartile range. [4]

Cedric took 14 seconds to solve the problem.

- (b) Determine whether Cedric's time is an outlier. [3]

(This question continues on the following page)



4. [Maximum mark: 6]

At a running club, Sung-Jin conducts a test to determine if there is any association between an athlete's age and their best time taken to run 100m. Eight athletes are chosen at random, and their details are shown below.

Athlete	A	B	C	D	E	F	G	H
Age (years)	13	17	22	18	19	25	11	36
Time (seconds)	13.4	14.6	13.4	12.9	12.0	11.8	17.0	13.1

Sung-Jin decides to calculate the Spearman's rank correlation coefficient for his set of data.

(a) Complete the table of ranks. [2]

Athlete	A	B	C	D	E	F	G	H
Age rank			3					
Time rank							1	

(b) Calculate the Spearman's rank correlation coefficient, r_s . [2]

(c) Interpret this value of r_s in the context of the question. [1]

(d) Suggest a mathematical reason why Sung-Jin may have decided not to use Pearson's product-moment correlation coefficient with his data from the original table. [1]

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5. [Maximum mark: 4]

The following frequency distribution table shows the test grades for a group of students.

Grade	1	2	3	4	5	6	7
Frequency	1	4	7	9	p	9	4

For this distribution, the mean grade is 4.5.

(a) Write down the total number of students in terms of p . [1]

(b) Calculate the value of p . [3]

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6. [Maximum mark: 6]

A company that owns many restaurants wants to determine if there are differences in the quality of the food cooked for three different meals: breakfast, lunch and dinner.

Their quality assurance team randomly selects 500 items of food to inspect. The quality of this food is classified as perfect, satisfactory, or poor. The data is summarized in the following table.

		Quality			Total
		Perfect	Satisfactory	Poor	
Meal	Breakfast	101	124	7	232
	Lunch	68	81	5	154
	Dinner	35	69	10	114
Total		204	274	22	500

An item of food is chosen at random from these 500.

- (a) Find the probability that its quality is not perfect, given that it is from breakfast. [2]

A χ^2 test at the 5% significance level is carried out to determine if there is significant evidence of a difference in the quality of the food cooked for the three meals.

The critical value for this test is 9.488.

The hypotheses for this test are:

- H_0 : The quality of the food and the type of meal are independent.
- H_1 : The quality of the food and the type of meal are not independent.

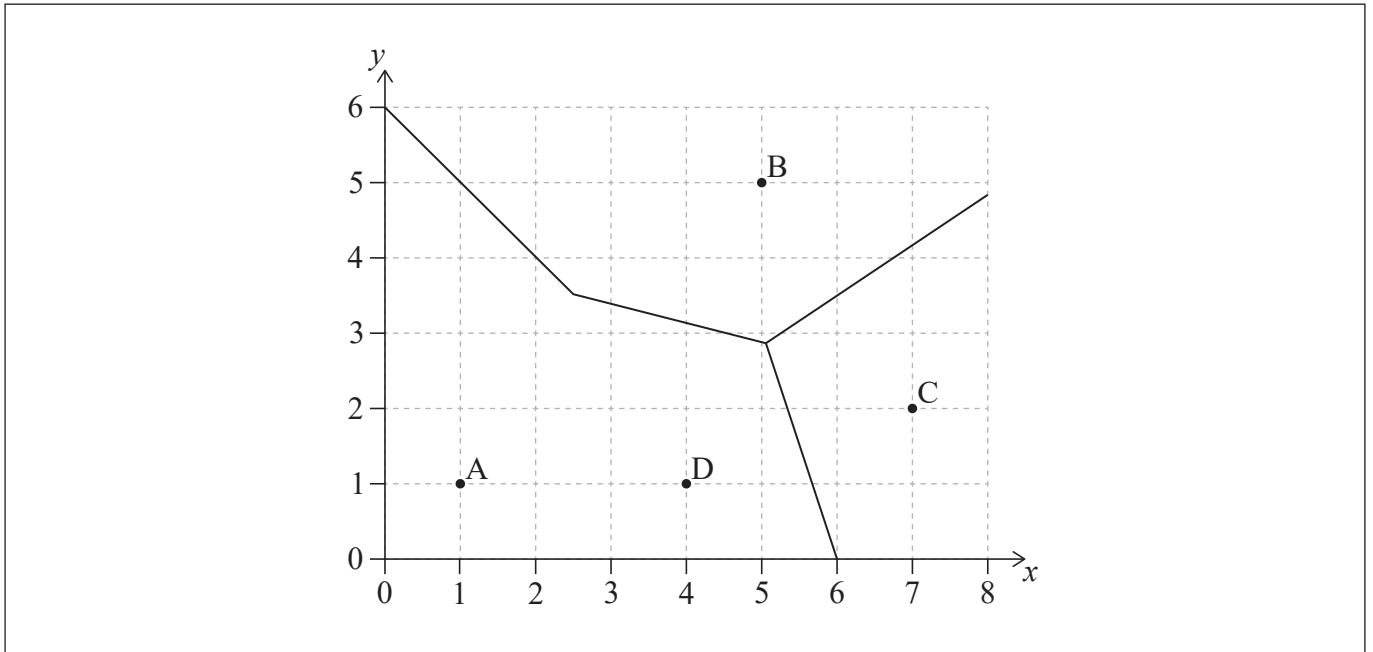
- (b) Find the χ^2 statistic. [2]
- (c) State, with justification, the conclusion for this test. [2]

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7. [Maximum mark: 6]

Ani owns four cafes represented by points A, B, C and D. Ani wants to divide the area into delivery regions. This process has been started in the following incomplete Voronoi diagram, where 1 unit represents 1 kilometre.



The midpoint of CD is (5.5, 1.5).

- (a) Show that the equation of the perpendicular bisector of [CD] is $y = -3x + 18$. [3]
- (b) Complete the Voronoi diagram shown above. [1]

Ani opens an office equidistant from three of the cafes, B, C and D. The equation of the perpendicular bisector of [BC] is $3y = 2x - 1.5$.

- (c) Find the coordinates of the office. [2]

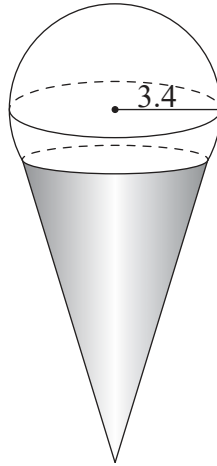
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8. [Maximum mark: 5]

Ruhi buys a scoop of ice cream in the shape of a sphere with a radius of 3.4 cm. The ice cream is served in a cone, and it may be assumed that $\frac{1}{5}$ of the volume of the ice cream is inside the cone. This is shown in the following diagram.

diagram not to scale



(a) Calculate the volume of ice cream that is not inside the cone. [3]

The cone has a slant height of 11 cm and a radius of 3 cm.

The outside of the cone is covered with chocolate.

(b) Calculate the surface area of the cone that is covered with chocolate. Give your answer correct to the nearest cm^2 . [2]

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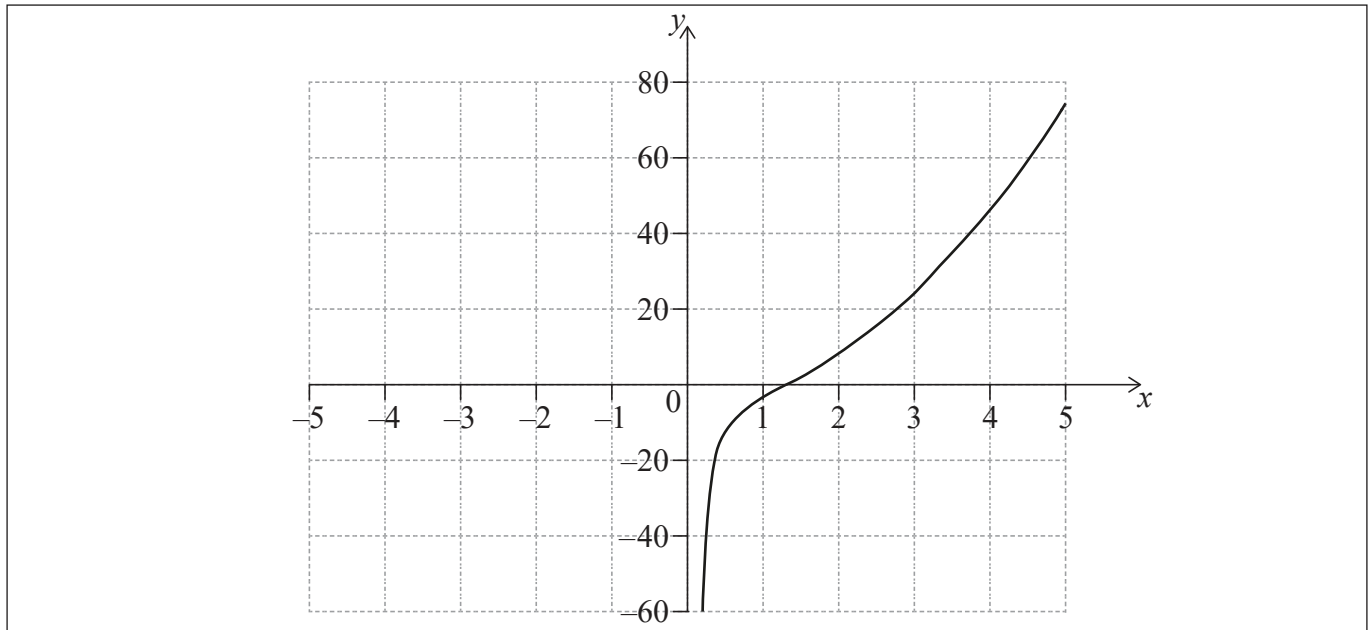
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11. [Maximum mark: 7]

Consider $f(x) = 3x^2 - \frac{5}{x}$, $x \neq 0$. The graph of f for $0 < x \leq 5$ is shown on the following axes.



- (a) (i) Sketch the graph of f , for $-5 \leq x < 0$, on the same axes.
- (ii) Write down the x -coordinate of the local minimum point. [4]
- (b) Use your graphic display calculator to find the solutions to the equation $f(x) = 20$. [2]
- (c) Write down the equation of the vertical asymptote for the graph of f . [1]

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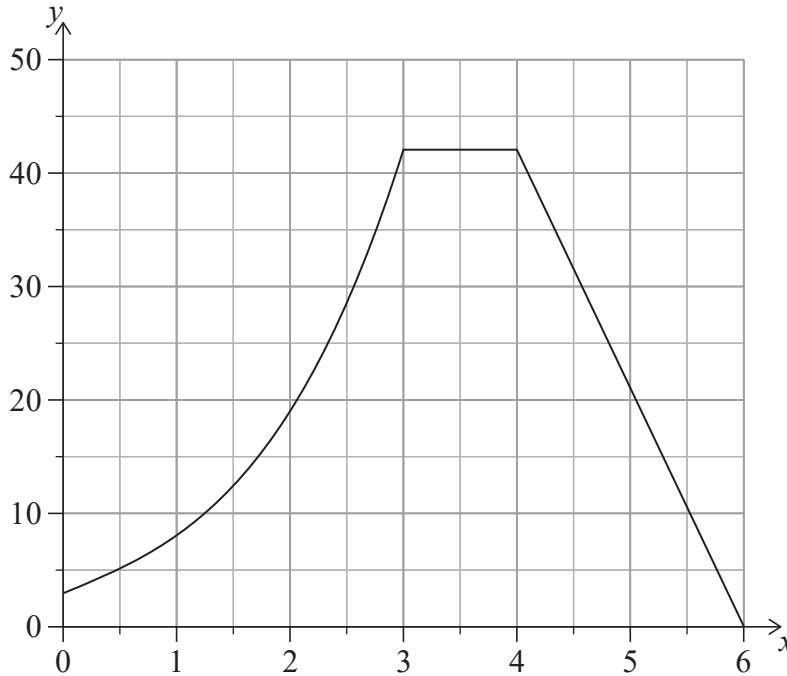
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20EP16

13. [Maximum mark: 9]

An engineer wants to calculate the cross-sectional area of a dam. The cross-section of the dam can be modelled by a curve and two straight lines as shown in the following diagram, where distances are measured in metres.



The curve is modelled by a function $f(x)$. The following table gives values of $f(x)$ for different values of x in the interval $0 \leq x \leq 3$.

x	0	0.5	1	1.5	2	2.5	3
$y = f(x)$	3	5.13	8	12.4	19	28.6	42

- (a) Calculate an estimate for the area in the interval $0 \leq x \leq 3$ by using the trapezoidal rule with three equal intervals. [2]

It is known that $f'(x) = 3x^2 + 4$ in the domain $0 < x < 3$.

- (b) Find an expression for $f(x)$, in the domain $0 < x < 3$. [4]
- (c) **Hence** find the actual area of the **entire** cross-section. [3]

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20EP20