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Mathematics: analysis and approaches
Standard level
Paper 2

2 May 2024

Zone A morning | **Zone B** morning | **Zone C** morning

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.
- Section A: answer all questions. Answers must be written within the answer boxes provided.
- Section B: answer all questions in the answer booklet provided. Fill in your session number on the front of the answer booklet, and attach it to this examination paper and your cover sheet using the tag 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: analysis and approaches SL formula booklet** is required for this paper.
- The maximum mark for this examination paper is **[80 marks]**.



Do **not** write solutions on this page.

Section B

Answer **all** questions in the answer booklet provided. Please start each question on a new page.

7. [Maximum mark: 14]

A lake contains a type of fish called carp. The lengths, L cm, of the carp can be modelled by a normal distribution with mean 45.6 cm and standard deviation 4.2 cm.

According to this model, carp with a length between 41.4 cm and k cm lie within one standard deviation of the mean.

- (a) Write down the value of k . [2]
- (b) Find the probability that a randomly selected carp is greater than 48 cm in length. [2]
- (c) It is known that 99% of carp in the lake have a length greater than x cm. Find the value of x . [2]
- (d) Consider a random sample of 100 carp from the lake.
- (i) Find the expected number of carp with lengths between 40 cm and 56 cm.
- (ii) Find the probability that in this sample, exactly 95 carp have a length between 40 cm and 56 cm. [5]

A large sample of carp from the lake is studied. The length of each fish is measured and recorded correct to the nearest 0.1 cm.

- (e) Find the probability that a randomly selected carp has a length recorded as 45.6 cm. [3]



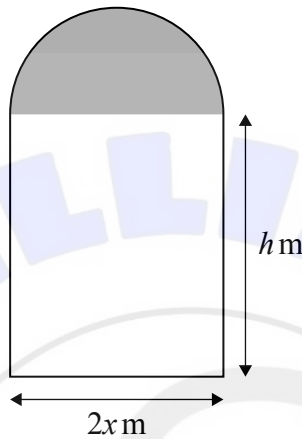
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8. [Maximum mark: 15]

A window is designed in the shape of a semicircle attached to a rectangle.

The rectangular section of the window has dimensions $2x$ metres by h metres.

The window consisting of its two sections is shown in the following diagram.



Let the area of the window be A square metres.

(a) Write down an expression for A in terms of x and h . [2]

Let the perimeter of the window be P metres.

(b) Given that $P = 10$, show that $h = \frac{1}{2}(10 - 2x - \pi x)$. [2]

The window is designed to let in the maximum amount of light.

The rectangular section of the window consists of clear glass and lets in three units of light per square metre.

The semicircular section of the window consists of tinted glass and lets in one unit of light per square metre.

(c) Show that the amount of light, L units, let in by the window is given by $L = 30x - 6x^2 - \frac{5}{2}\pi x^2$. [4]

- (d) (i) Find an expression for $\frac{dL}{dx}$.
- (ii) Find the value of x so that the window lets in the maximum amount of light. Justify that this value of x gives a maximum.
- (iii) Find the value of h so that the window lets in the maximum amount of light. [7]



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9. [Maximum mark: 17]

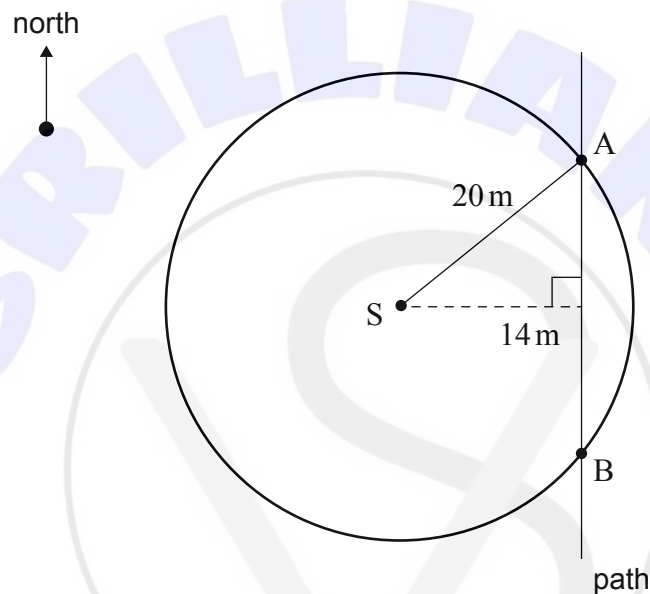
A rotating sprinkler is at a fixed point S .

It waters all points inside and on a circle of radius 20 metres.

Point S is 14 metres from the edge of a path which runs in a north-south direction.

The edge of the path intersects the circle at points A and B .

This information is shown in the following diagram.



(a) Show that $AB = 28.57$, correct to four significant figures. [3]

The sprinkler rotates at a constant rate of one revolution every 16 seconds.

(b) Show that the sprinkler rotates through an angle of $\frac{\pi}{8}$ radians in one second. [1]

Let T seconds be the time that $[AB]$ is watered in each revolution.

(c) Find the value of T . [4]

(This question continues on the following page)



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(Question 9 continued)

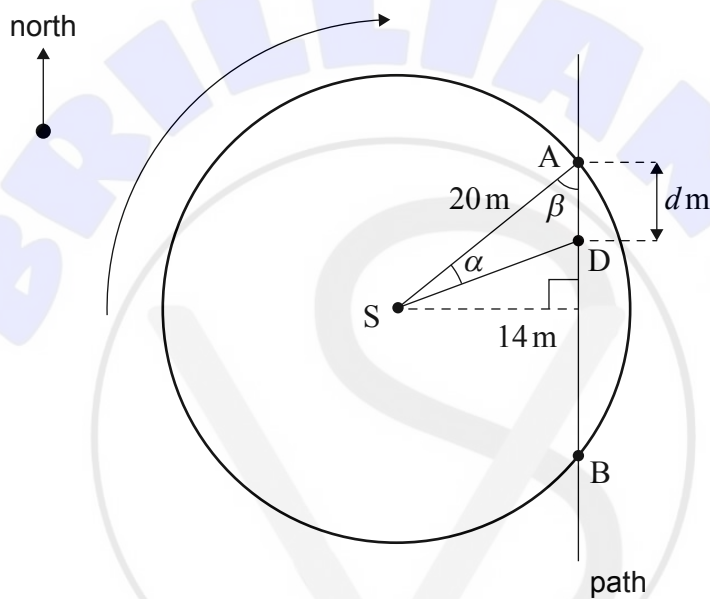
Consider one clockwise revolution of the sprinkler.

At $t = 0$, the water crosses the edge of the path at A.

At time t seconds, the water crosses the edge of the path at a movable point D which is a distance d metres south of point A.

Let $\alpha = \widehat{ASD}$ and $\beta = \widehat{SAB}$, where α, β are measured in radians.

This information is shown in the following diagram.



- (d) Write down an expression for α in terms of t . [1]

It is known that $\beta = 0.7754$ radians, correct to four significant figures.

- (e) By using the sine rule in $\triangle ASD$, show that the distance, d , at time t , can be modelled by

$$d(t) = \frac{20 \sin\left(\frac{\pi t}{8}\right)}{\sin\left(2.37 - \frac{\pi t}{8}\right)}. \quad [3]$$

(This question continues on the following page)



Do **not** write solutions on this page.

(Question 9 continued)

A turtle walks south along the edge of the path.

At time t seconds, the turtle's distance, g metres south of A, can be modelled by

$$g(t) = 0.05t^2 + 1.1t + 18, \text{ where } t \geq 0.$$

- (f) At $t = 0$, state how far south the turtle is from A. [1]

Let w represent the distance between the turtle and point D at time t seconds.

- (g) (i) Use the expressions for $g(t)$ and $d(t)$ to write down an expression for w in terms of t .
(ii) Hence find when and where on the path the water first reaches the turtle. [4]

