



CANDIDATE  
NAME

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CENTRE  
NUMBER

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CANDIDATE  
NUMBER

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## 0606/13

May/June 2023

**2 hours**

No additional materials are needed.

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].

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**[Turn over**

**Mathematical Formulae****1. ALGEBRA***Quadratic Equation*

For the equation  $ax^2 + bx + c = 0$ ,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

*Binomial Theorem*

$$(a+b)^n = a^n + \binom{n}{1}a^{n-1}b + \binom{n}{2}a^{n-2}b^2 + \dots + \binom{n}{r}a^{n-r}b^r + \dots + b^n$$

where  $n$  is a positive integer and  $\binom{n}{r} = \frac{n!}{(n-r)!r!}$

*Arithmetic series*  $u_n = a + (n-1)d$

$$S_n = \frac{1}{2}n(a+l) = \frac{1}{2}n\{2a + (n-1)d\}$$

*Geometric series*  $u_n = ar^{n-1}$

$$S_n = \frac{a(1-r^n)}{1-r} \quad (r \neq 1)$$

$$S_\infty = \frac{a}{1-r} \quad (|r| < 1)$$

**2. TRIGONOMETRY***Identities*

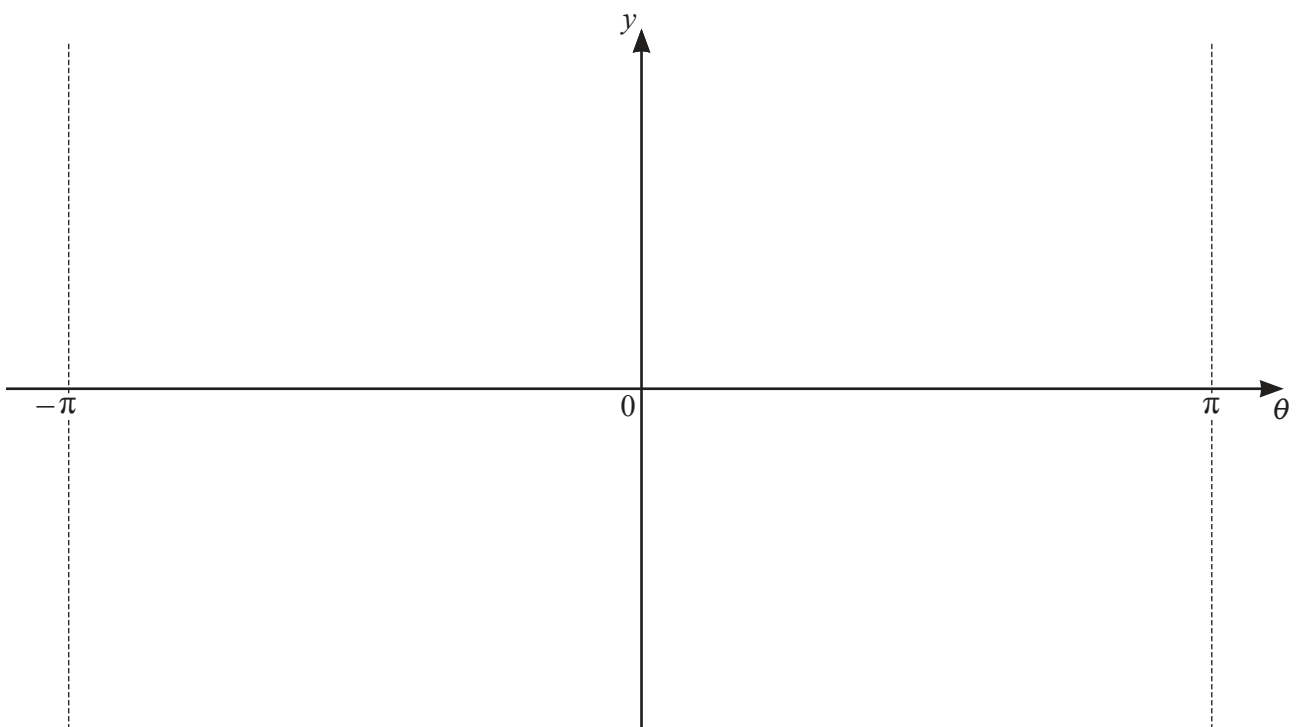
$$\begin{aligned}\sin^2 A + \cos^2 A &= 1 \\ \sec^2 A &= 1 + \tan^2 A \\ \operatorname{cosec}^2 A &= 1 + \cot^2 A\end{aligned}$$

*Formulae for  $\triangle ABC$* 

$$\begin{aligned}\frac{a}{\sin A} &= \frac{b}{\sin B} = \frac{c}{\sin C} \\ a^2 &= b^2 + c^2 - 2bc \cos A \\ \Delta &= \frac{1}{2}bc \sin A\end{aligned}$$

- 1 (a) Write down the period, in radians, of  $3 \tan \frac{\theta}{2} - 3$ . [1]

- (b) On the axes, sketch the graph of  $y = 3 \tan \frac{\theta}{2} - 3$  for  $-\pi \leq \theta \leq \pi$ , stating the coordinates of the points where the graph meets the axes. [3]



2 (a) Write  $2x^2 + 5x + 3$  in the form  $2(x + a)^2 + b$ , where  $a$  and  $b$  are rational numbers. [2]

(b) Hence write down the coordinates of the stationary point on the curve  $y = 2x^2 + 5x + 3$ . [2]

(c) Solve the inequality  $2x^2 + 5x + 3 < \frac{15}{8}$ . [3]

- 3 (a) Write  $3 + 2 \lg a - \frac{1}{2} \lg(4b^2)$ , where  $a$  and  $b$  are both positive, as a single logarithm to base 10. Give your answer in its simplest form. [3]

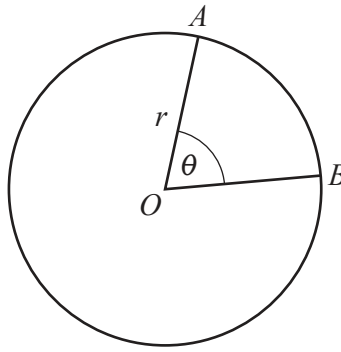
- (b) Given that  $2 \log_c 3 = 7 + 4 \log_3 c$ , find the possible values of the positive constant  $c$ , giving your answers in exact form. [5]

- 4 The straight line  $y = 3x - 11$  and the curve  $xy = 4 - 3x - 2x^2$  intersect at the points  $A$  and  $B$ . The point  $C$ , with coordinates  $(a, -8)$  where  $a$  is a constant, lies on the perpendicular bisector of the line  $AB$ . Find the value of  $a$ . [8]

- 5 (a) Find the first three terms in the expansion of  $\left(x^2 - \frac{4}{x^2}\right)^{10}$  in descending powers of  $x$ . Give each term in its simplest form. [3]

- (b) Hence find the coefficient of  $x^{16}$  in the expansion of  $\left(x^2 - \frac{4}{x^2}\right)^{10} \left(x^2 + \frac{2}{x^2}\right)^2$ . [3]

- 6 In this question lengths are in centimetres and angles are in radians.



The diagram shows a circle with centre  $O$  and radius  $r$ . The points  $A$  and  $B$  lie on the circumference of the circle. The area of the minor sector  $OAB$  is  $25\text{ cm}^2$ . The angle  $AOB$  is  $\theta$ .

- (a) Find an expression for the perimeter,  $P$ , of the minor sector  $AOB$ , in terms of  $r$ . [3]



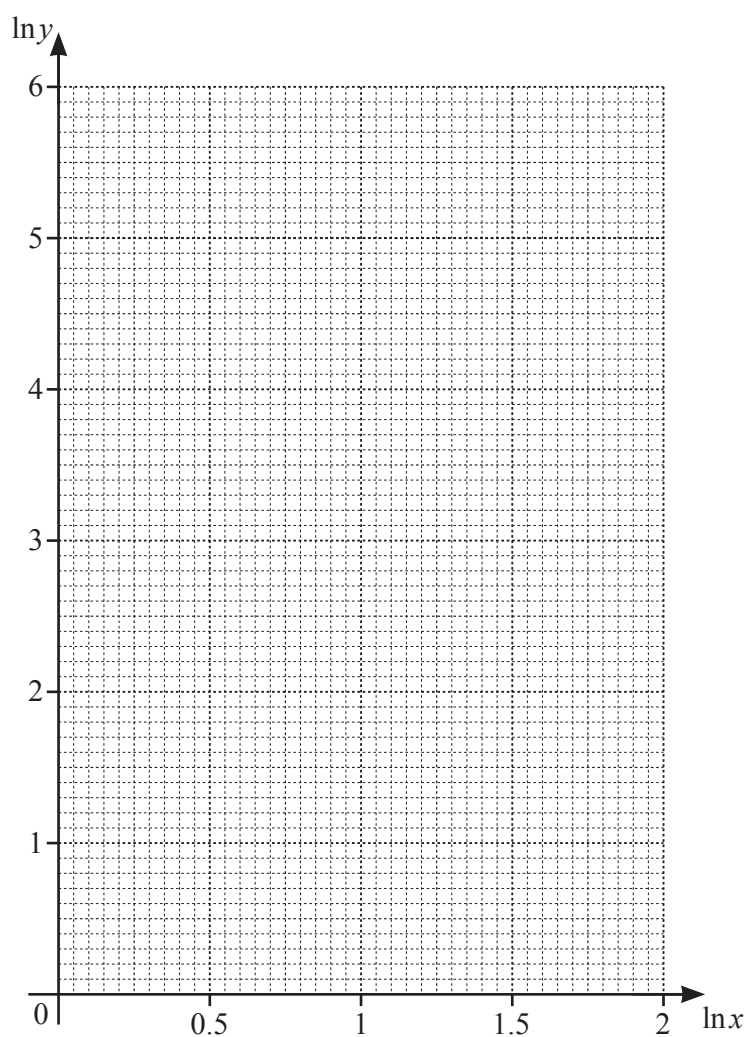
- (b) Given that  $r$  can vary, show that  $P$  has a minimum value and find this minimum value. [4]

- 7 The table shows values of the variables  $x$  and  $y$  which are related by an equation of the form  $y = Ax^b$ , where  $A$  and  $b$  are constants.

$x$	1.5	2	2.5	3	4
$y$	13.8	27.5	46.9	72.6	145

- (a) Use the data to draw a straight line graph of  $\ln y$  against  $\ln x$ .

[3]

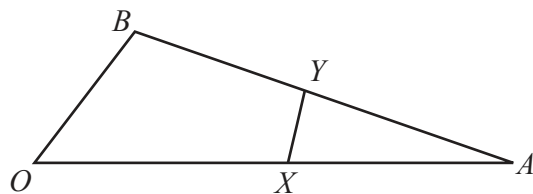


(b) Use your graph to estimate the values of  $A$  and  $b$ .

[5]

(c) Estimate the value of  $x$  when  $y = 100$ .

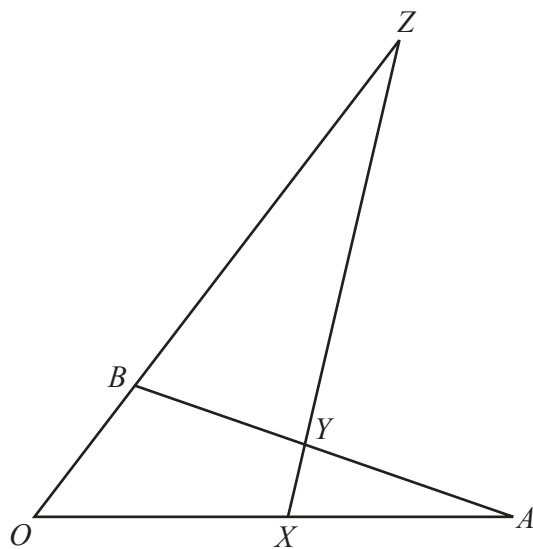
[2]



The diagram shows the triangle  $OAB$  with  $\overrightarrow{OA} = \mathbf{a}$  and  $\overrightarrow{OB} = \mathbf{b}$ . The point  $X$  lies on the line  $OA$  such that  $\overrightarrow{OX} = \frac{3}{5}\mathbf{a}$ . The point  $Y$  is the mid-point of the line  $AB$ . Find, in terms of  $\mathbf{a}$  and  $\mathbf{b}$ ,

(a)  $\overrightarrow{AB}$  [1]

(b)  $\overrightarrow{XY}$ . [2]



The lines  $OB$  and  $XY$  are extended to meet at the point  $Z$ . It is given that  $\overrightarrow{YZ} = \lambda\overrightarrow{XY}$  and  $\overrightarrow{BZ} = \mu\mathbf{b}$ .

(c) Find  $\overrightarrow{XZ}$  in terms of  $\lambda$ ,  $\mathbf{a}$  and  $\mathbf{b}$ . [2]

(d) Find  $\overrightarrow{XZ}$  in terms of  $\mu$ ,  $\mathbf{a}$  and  $\mathbf{b}$ . [2]

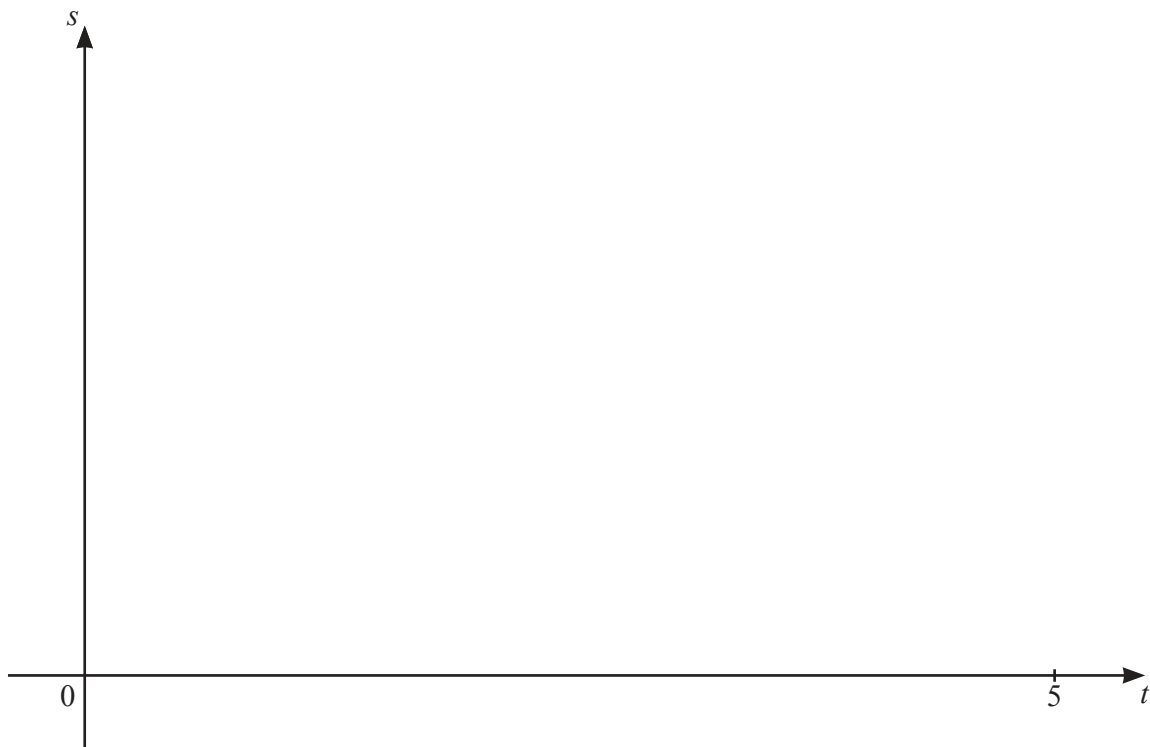
(e) Hence find the values of  $\lambda$  and  $\mu$ . [3]

- 9 In this question lengths are in centimetres and time is in seconds.

A particle  $P$  moves in a straight line such that its displacement  $s$ , from a fixed point at a time  $t$ , is given by  $s = 3(t+2)(t-4)^2$  for  $0 \leq t \leq 5$ .

- (a) Find the values of  $t$  for which the velocity,  $v$ , of  $P$  is zero. [4]

- (b) On the axes below, sketch the displacement–time graph of  $P$ , stating the intercepts with the axes. [3]



- (c) On the axes below, sketch the velocity–time graph of  $P$ , stating the intercepts with the axes. [2]



- (d) (i) Find an expression for the acceleration of  $P$  at time  $t$ . [1]

- (ii) Hence, on the axes below, sketch the acceleration–time graph of  $P$ , stating the intercepts with the axes. [2]



**Question 10 is printed on the next page.**

10 (a) Show that  $\cos^4 \theta - \sin^4 \theta + 1 = 2 \cos^2 \theta$ .

[3]

(b) Solve the equation  $\cos^4 \frac{\phi}{3} - \sin^4 \frac{\phi}{3} + 1 = \frac{1}{2}$ , for  $-3\pi < \phi < 3\pi$ , giving your answers in terms of  $\pi$ . [5]

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