Please check the examination details below before entering your candidate information

Candidate surname StemUp Model Solution | Other names

Centre Number | Candidate Number

# Pearson Edexcel International Advanced Level

## Tuesday 21 October 2025

Afternoon (Time: 1 hour 30 minutes) | Paper reference **WMA13/01**

# Mathematics

## International Advanced Level
## Pure Mathematics P3

**You must have:**
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

**Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.**

## Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

## Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 9 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

## Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

*Turn over* ▶

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**1.** **In this question you must show all stages of your working.**
**Solutions relying entirely on calculator technology are not acceptable.**

The functions f and g are defined by

$$f(x) = \ln(x^2 + 3) \qquad x \in \mathbb{R}$$

$$g(x) = \frac{3 + 5x}{x + 2} \qquad x \in \mathbb{R} \quad x > -2$$

(a) State the range of f

**(1)**

(b) Find $g^{-1}$

**(3)**

(c) Find $fg(0)$

**(2)**

(d) Find the exact value of $a$ for which

$$g\left(e^{2a}\right) = f\left(\sqrt{e^4 - 3}\right)$$

**(3)**

(a) $f(x) \geq \ln 3$

(b) $y = \frac{3 + 5x}{x + 2} \Rightarrow xy + 2y = 3 + 5x$

$xy - 5x = 3 - 2y \Rightarrow x(y - 5) = 3 - 2y$

$x = \frac{3 - 2y}{y - 5}$

$g^{-1}(x) = \frac{3 - 2x}{x - 5}, \quad x < 5$

(c) $g(0) = \frac{3 + 0}{0 + 2} = \frac{3}{2}$

$fg(0) = f\left(\frac{3}{2}\right) = \ln\left(\frac{9}{4} + 3\right) = \ln\left(\frac{21}{4}\right)$

(d) $f(\sqrt{(e^4 - 3)}) = \ln(e^4 - 3 + 3) = \ln(e^4) = 4$

$g(e^{2a}) = 4 \Rightarrow \frac{3 + 5e^{2a}}{e^{2a} + 2} = 4$

$3 + 5e^{2a} = 4e^{2a} + 8$

$e^{2a} = 5 \Rightarrow 2a = \ln 5$

$a = \frac{1}{2}\ln 5$

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**Question 1 continued**

**Question 1 continued**

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**Question 1 continued**

**(Total for Question 1 is 9 marks)**

**2.**

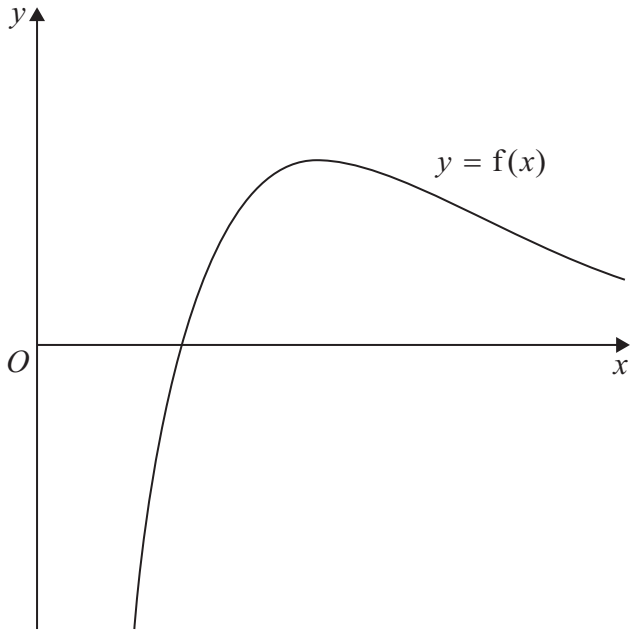



**Figure 1**

Figure 1 shows a sketch of part of the curve with equation $y = f(x)$ where

$$f(x) = \frac{2x^2 + 3x - 4}{e^x} - \frac{1}{x^2} \qquad x \in \mathbb{R} \quad x \neq 0$$

(a) Show that $f(x) = 0$ has a root $\alpha$ in the interval $[1, 2]$

**(2)**

(b) Show that the equation $f(x) = 0$ can be written in the form

$$x = \sqrt[3]{\frac{e^x + 4x^2}{2x + 3}}$$

**(2)**

Using the iteration formula

$$x_{n+1} = \sqrt[3]{\frac{e^{x_n} + 4x_n^2}{2x_n + 3}} \qquad \text{with } x_1 = 1$$

find, to 4 decimal places,

(c) (i) the value of $x_3$

(ii) the value of $\alpha$

**(3)**

(a) $f(1) = \frac{2 + 3 - 4}{e^1} - \frac{1}{1^2} = -0.632... < 0$

$f(2) = \frac{8 + 6 - 4}{e^2} - \frac{1}{2^2} = 1.103... > 0$

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**Question 2 continued**

Sign change and $f(x)$ is continuous on $[1, 2]$,

so there is a root $\alpha$ in the interval $[1, 2]$

(b) $\dfrac{2x^2 + 3x - 4}{e^x} - \dfrac{1}{x^2} = 0 \Rightarrow \dfrac{2x^2 + 3x - 4}{e^x} = \dfrac{1}{x^2}$

$x^2(2x^2 + 3x - 4) = e^x$

$2x^4 + 3x^3 - 4x^2 = e^x \Rightarrow 2x^4 + 3x^3 = e^x + 4x^2$

$x^3(2x + 3) = e^x + 4x^2$

$x^3 = \dfrac{e^x + 4x^2}{2x + 3} \Rightarrow x = \sqrt[3]{\dfrac{e^x + 4x^2}{2x + 3}}$

(c)(i) $x_2 = \sqrt[3]{\dfrac{e^1 + 4(1)^2}{2(1) + 3}} = 1.10347...$

$x_3 = 1.14835... \Rightarrow x_3 = 1.1484$ (4 d.p.)

(ii) $x_4 = 1.16744...$, $x_5 = 1.17550...$, $x_6 = 1.17888...$

$x_7 = 1.18030...$, $x_8 = 1.18090...$, ..., $x_{12} = 1.18131...$

$x_{15} = 1.18133...$, $x_{16} = 1.18133...$

$\alpha = 1.1813$ (4 d.p.)

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**Question 2 continued**

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**Question 2 continued**

**(Total for Question 2 is 7 marks)**

**3.** The share price, £$V$, of a company is being monitored.

A graph is drawn of $\log_{10} V$ against $t$, where $t$ is the number of years after monitoring began.

The graph is a straight line passing through the points $(0, 2)$ and $(5, 2.25)$

Using this information,

(a) find an equation for the line in the form

$$\log_{10} V = mt + c$$

where $m$ and $c$ are constants.

**(2)**

(b) Write the answer to part (a) in the form

$$V = ab^t$$

where $a$ and $b$ are constants to be found.

Give the exact value of $a$ and the value of $b$ to 3 significant figures.

**(3)**

When $t = T$, the rate of increase in the share price of the company was £50 per year.

(c) Find the value of $T$, giving your answer to the nearest integer.

(*Solutions relying entirely on calculator technology are not acceptable.*)

**(4)**

(a) $m = \frac{2.25 - 2}{5 - 0} = 0.05, \quad c = 2$

$\log_{10} V = 0.05t + 2$

(b) $V = 10^{0.05t + 2} = 10^2 \times (10^{0.05})^t$

$10^{0.05} = 1.12201... \Rightarrow a = 100, \quad b = 1.12$

$V = 100 \times (1.12)^t$

(c) $\frac{dV}{dt} = 100 \times \ln 1.12 \times (1.12)^t$

$100 \ln 1.12 \times (1.12)^T = 50$

$(1.12)^T = \frac{50}{100 \ln 1.12} = 4.4119...$

$T = \log_{1.12}\left(\frac{50}{100 \ln 1.12}\right) = \frac{\ln 4.4119...}{\ln 1.12} = 13.097...$

$T = 13$

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**Question 3 continued**

**Question 3 continued**

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**Question 3 continued**

**(Total for Question 3 is 9 marks)**

**4.** **In this question you must show all stages of your working.**
**Solutions relying entirely on calculator technology are not acceptable.**

(a) $f(x) = \sqrt{3}\sin 2x - 3\cos 2x$

Express $f(x)$ in the form $R\sin(2x - \alpha)$, where $R$ and $\alpha$ are constants,

$$R > 0 \text{ and } 0 < \alpha < \frac{\pi}{2}$$

Give the exact value of $R$ and the exact value of $\alpha$.

**(3)**

(b) $$g(x) = \frac{18}{f(3x) + 4\sqrt{3}} \qquad x > 0$$

Using the answer to part (a),

(i) write down the exact minimum value of $g(x)$,

(ii) find the smallest value of $x$ for which this minimum value occurs.

You must make your method clear.

**(3)**

(a) $R\sin(2x - \alpha) = R\sin 2x\cos\alpha - R\cos 2x\sin\alpha$

$R\cos\alpha = \sqrt{3}, \quad R\sin\alpha = 3$

$R = \sqrt{(\sqrt{3})^2 + 3^2} = \sqrt{12} = 2\sqrt{3}$

$\tan\alpha = \frac{3}{\sqrt{3}} = \sqrt{3} \Rightarrow \alpha = \frac{\pi}{3}$

$f(x) = 2\sqrt{3}\sin\left(2x - \frac{\pi}{3}\right)$

(b)(i) $f(3x) = 2\sqrt{3}\sin\left(6x - \frac{\pi}{3}\right)$, least $g$ when the sine term $= 1$

minimum $g(x) = \frac{18}{2\sqrt{3} + 4\sqrt{3}} = \frac{18}{6\sqrt{3}} = \frac{3}{\sqrt{3}} = \sqrt{3}$

(ii) $\sin\left(6x - \frac{\pi}{3}\right) = 1 \Rightarrow 6x - \frac{\pi}{3} = \frac{\pi}{2}$

$6x = \frac{5\pi}{6} \Rightarrow x = \frac{5\pi}{36}$

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**Question 4 continued**

**(Total for Question 4 is 6 marks)**

**5.** **In this question you must show all stages of your working.**
**Solutions relying entirely on calculator technology are not acceptable.**

The number of squirrels in a forest is being studied.

The number of squirrels, $N$, in the forest, $t$ years after the start of the study, is modelled by the equation

$$N = \frac{4000e^{0.1t}}{19 + e^{0.2t}} \qquad t \geqslant 0$$

**Use the equation of the model to answer parts (a), (b), (c) and (d).**

(a) Find the number of squirrels in the forest at the start of the study.

**(1)**

(b) Find $\frac{dN}{dt}$

**(2)**

The number of squirrels in the forest is at a maximum when $t = T$

Using the answer to part (b),

(c) show that $e^{0.2T} = A$, where $A$ is a constant to be found.

**(2)**

(d) Hence find the maximum number of squirrels in the forest.

Show your working and give your answer to the nearest whole number.

**(3)**

(a) $t = 0$: $N = \frac{4000e^0}{19 + e^0} = \frac{4000}{20} = 200$

(b) $\frac{dN}{dt} = \frac{(19 + e^{0.2t}) \times 400e^{0.1t} - 4000e^{0.1t} \times 0.2e^{0.2t}}{(19 + e^{0.2t})^2}$

$= \frac{7600e^{0.1t} + 400e^{0.3t} - 800e^{0.3t}}{(19 + e^{0.2t})^2} = \frac{7600e^{0.1t} - 400e^{0.3t}}{(19 + e^{0.2t})^2}$

(c) Maximum when $\frac{dN}{dt} = 0$: $7600e^{0.1T} - 400e^{0.3T} = 0$

$400e^{0.3T} = 7600e^{0.1T}$

$e^{0.2T} = 19$, $A = 19$

(d) $0.2T = \ln 19 \Rightarrow T = \frac{\ln 19}{0.2} = 14.722...$

$e^{0.1T} = \sqrt{19}$, $e^{0.2T} = 19$

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**Question 5 continued**

$$N = \frac{4000e^{0.1 \times 14.722...}}{19 + e^{0.2 \times 14.722...}} = \frac{4000\sqrt{19}}{19 + 19} = 458.83...$$

Maximum number of squirrels = 459

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**Question 5 continued**

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**Question 5 continued**

**(Total for Question 5 is 8 marks)**

**6.** **In this question you must show all stages of your working.**
**Solutions relying entirely on calculator technology are not acceptable.**

(i) Given $y = \ln(2x^2 + 5)$ find $\dfrac{dy}{dx}$

**(2)**

(ii) A curve $C$ has equation $y = f(x)$ where

$$f(x) = \frac{21x}{3x^2 + k} \qquad x \in \mathbb{R}$$

where $k$ is a positive integer, $k > 1$

Given that

$$\int_1^k f(x)\,dx < 7\ln 8$$

find the greatest possible value of $k$

**(5)**

(i) $\dfrac{dy}{dx} = \dfrac{4x}{2x^2 + 5}$

(ii) $\displaystyle\int \frac{21x}{3x^2 + k}\,dx = \frac{21}{6}\ln(3x^2 + k) = \frac{7}{2}\ln(3x^2 + k) \quad (+c)$

$\displaystyle\int_1^k f(x)\,dx = \left[\frac{7}{2}\ln(3x^2 + k)\right]_1^k = \frac{7}{2}\ln(3k^2 + k) - \frac{7}{2}\ln(3 + k)$

$\dfrac{7}{2}\ln\left(\dfrac{3k^2 + k}{3 + k}\right) < 7\ln 8 \Rightarrow \ln\left(\dfrac{3k^2 + k}{3 + k}\right) < 2\ln 8 = \ln 64$

$\dfrac{3k^2 + k}{3 + k} < 64 \quad (3 + k > 0)$

$3k^2 + k < 192 + 64k \Rightarrow 3k^2 - 63k - 192 < 0$

$k^2 - 21k - 64 < 0$

Critical values: $k = \dfrac{21 \pm \sqrt{21^2 + 4 \times 64}}{2} = \dfrac{21 \pm \sqrt{697}}{2}$

$k = 23.70\ldots$ or $k = -2.70\ldots \Rightarrow -2.70\ldots < k < 23.70\ldots$

Greatest possible integer $k = 23$

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**Question 6 continued**

**(Total for Question 6 is 7 marks)**

**7.** **In this question you must show all stages of your working.**
**Solutions relying entirely on calculator technology are not acceptable.**

A curve $C$ has equation

$$y = 2xe^{x^2+(3k-2)x}$$

where $k$ is a constant.

Given that $C$ has two distinct turning points, find the range of possible values of $k$.

**(7)**

$y = 2xe^{x^2 + (3k - 2)x}$ (product rule)

$\frac{dy}{dx} = 2e^{x^2 + (3k - 2)x} + 2xe^{x^2 + (3k - 2)x} \times (2x + 3k - 2)$

$\frac{dy}{dx} = 2e^{x^2 + (3k - 2)x}(2x^2 + (3k - 2)x + 1)$

Turning points: $\frac{dy}{dx} = 0$, and $e^{x^2 + (3k - 2)x} > 0$, so

$2x^2 + (3k - 2)x + 1 = 0$

Two distinct turning points $\Rightarrow b^2 - 4ac > 0$

$(3k - 2)^2 - 4 \times 2 \times 1 > 0$

$9k^2 - 12k + 4 - 8 > 0 \Rightarrow 9k^2 - 12k - 4 > 0$

$9k^2 - 12k - 4 = 0 \Rightarrow k = \frac{12 \pm \sqrt{(-12)^2 - 4 \times 9 \times (-4)}}{2 \times 9} = \frac{12 \pm \sqrt{288}}{18}$

$k = \frac{12 \pm 12\sqrt{2}}{18} = \frac{2 \pm 2\sqrt{2}}{3}$

$k < \frac{2 - 2\sqrt{2}}{3}$ or $k > \frac{2 + 2\sqrt{2}}{3}$

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**Question 7 continued**

**Question 7 continued**

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**Question 7 continued**

**(Total for Question 7 is 7 marks)**

**8.**

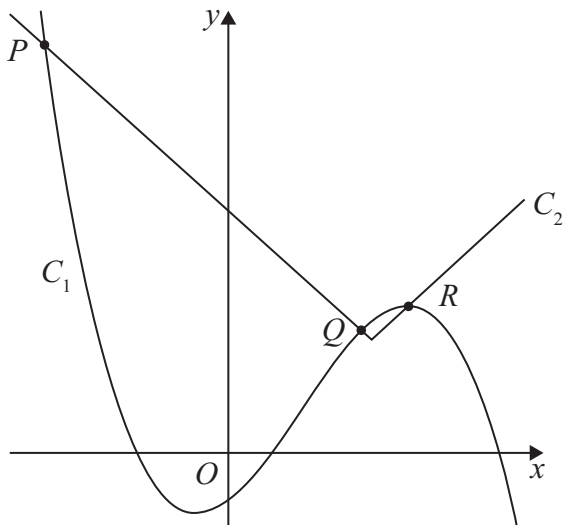



**Figure 2**

Figure 2 shows a sketch of the graph $C_1$ with equation

$$y = -2x^3 + 5x^2 + 4x - 3$$

and a sketch of the graph $C_2$ with equation

$$y = a + |5x + b|$$

where $a$ and $b$ are constants.

Graphs $C_1$ and $C_2$ intersect at point $P$, point $Q$ and point $R$, as shown in Figure 2.

Given that $P$ has coordinates $(-2, 25)$

(a) show that

$$a = 15 + b$$

**(2)**

Given also that $R$ has coordinates $(2, 9)$

(b) find the value of $a$ and the value of $b$

**(3)**

Using the answer to part (b),

(c) state the coordinates of the vertex of $C_2$

**(2)**

(d) Find, using algebra, the coordinates of $Q$. Show each stage of your working.

(*Solutions relying on calculator technology are not acceptable.*)

**(6)**

(a) P(−2, 25) is on the branch $y = a - (5x + b)$:

$25 = a - (5 \times (-2) + b) = a + 10 - b$

$\Rightarrow a = 15 + b$ as required

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**Question 8 continued**

(b) $R(2, 9)$ is on the branch $y = a + (5x + b)$:

$9 = a + 10 + b \Rightarrow a + b = -1$

$15 + b + b = -1 \Rightarrow 2b = -16$

$a = 7, \quad b = -8$

(c) $C_2$: $y = 7 + |5x - 8|$, vertex where $5x - 8 = 0$

Vertex $\left(\frac{8}{5}, 7\right)$

(d) $Q$ is on the left branch: $y = 7 - (5x - 8) = 15 - 5x$

$15 - 5x = -2x^3 + 5x^2 + 4x - 3$

$2x^3 - 5x^2 - 9x + 18 = 0$

$x = -2$ is a root (point $P$): $2(-8) - 5(4) + 18 + 18 = 0$

$2x^3 - 5x^2 - 9x + 18 = (x + 2)(2x^2 - 9x + 9)$

$2x^2 - 9x + 9 = 0 \Rightarrow (2x - 3)(x - 3) = 0$

$x = \frac{3}{2}$ ($x = 3$ rejected as $Q$ has $x < \frac{8}{5}$)

$y = 15 - 5 \times \frac{3}{2} = \frac{15}{2}$

$Q\left(\frac{3}{2}, \frac{15}{2}\right)$

**Question 8 continued**

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**Question 8 continued**

**(Total for Question 8 is 13 marks)**

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**9.** **In this question you must show all stages of your working.**
**Solutions relying entirely on calculator technology are not acceptable.**

(a) Express

$$6\sin^2\theta\cot 2\theta + 4\sin\theta\cos\theta$$

in terms of $\sin 2\theta$ and $\cos 2\theta$ only.

**(3)**

(b) Hence show that the equation

$$3\cot 2\theta - 14 = 6\sin^2\theta\cot 2\theta + 4\sin\theta\cos\theta$$

can be written in the form

$$5\sin^2 2\theta + 14\sin 2\theta - 3 = 0$$

**(3)**

(c) Hence solve, for $0 < x < 90°$, the equation

$$3\cot 2x - 14 = 6\sin^2 x\cot 2x + 4\sin x\cos x$$

giving your answers to one decimal place.

**(3)**

(a) $4\sin\theta\cos\theta = 2\sin 2\theta$, $\quad 6\sin^2\theta = 3(1 - \cos 2\theta) = 3 - 3\cos 2\theta$

$$\cot 2\theta = \frac{\cos 2\theta}{\sin 2\theta}$$

$$6\sin^2\theta\cot 2\theta + 4\sin\theta\cos\theta = (3 - 3\cos 2\theta)\frac{\cos 2\theta}{\sin 2\theta} + 2\sin 2\theta$$

(b) $3\cot 2\theta - 14 = (3 - 3\cos 2\theta)\frac{\cos 2\theta}{\sin 2\theta} + 2\sin 2\theta$

$$3\cot 2\theta - 14 = 3\cot 2\theta - \frac{3\cos^2 2\theta}{\sin 2\theta} + 2\sin 2\theta$$

$$-14 = -\frac{3\cos^2 2\theta}{\sin 2\theta} + 2\sin 2\theta$$

$\times \sin 2\theta$: $\quad -14\sin 2\theta = -3\cos^2 2\theta + 2\sin^2 2\theta$

$-14\sin 2\theta = -3(1 - \sin^2 2\theta) + 2\sin^2 2\theta = -3 + 5\sin^2 2\theta$

$5\sin^2 2\theta + 14\sin 2\theta - 3 = 0$ $\quad$ as required

(c) $5\sin^2 2x + 14\sin 2x - 3 = 0 \Rightarrow (5\sin 2x - 1)(\sin 2x + 3) = 0$

$\sin 2x = \frac{1}{5}$ $\quad (\sin 2x = -3$ has no solutions)

$2x = \sin^{-1}\left(\frac{1}{5}\right) = 11.536...°, \quad 180° - 11.536...° = 168.463...°$

$x = 5.8°, \quad x = 84.2°$

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**Question 9 continued**

**Question 9 continued**

**(Total for Question 9 is 9 marks)**

**TOTAL FOR PAPER IS 75 MARKS**

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