JZ Mock Set A Paper 1

Recommended time: 2 hours

Calculators: not permitted

Format: 20 multiple-choice questions

This is a TMUA-style mock paper modelled on the Test of Mathematics for University Admission. The TMUA is used in admissions for mathematics, economics, computer science, and engineering courses at universities including Cambridge, Oxford, Imperial College London, UCL, LSE, Warwick, and Durham.

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Paper Guidance

- These papers contain only hard, very hard, and occasionally *unreasonably hard* TMUA-style questions :). I have deliberately left out the routine and easier material, so please do not be discouraged if you find a paper difficult or need longer than the recommended time. That is exactly how it is meant to feel. Take your time, enjoy the challenge, and remember that struggling with difficult problems is one of the best ways to get better.
- As a rough and deliberately conservative guide, a student who scores above 27 out of 40 across one full set, meaning both papers in four hours, is very likely already working at around the 7.0+ level on the current TMUA scale. However, this is only intended as a guide, not something to worry about too much. The main purpose of these papers is improvement rather than measurement: meet difficult problems, struggle with them, learn from them, and focus on getting better each time.

Best of luck, and enjoy the challenge!

Last updated: 30 September 2026 at 21:38

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Question 1

Find the finite area enclosed between the curve $y = |x^2 - 1|$ and the line $y = 3$.

A $\frac{13}{3}$

B 4

C 8

D $\frac{25}{3}$

E $\frac{23}{3}$

F $\frac{11}{3}$

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Question 2

The equation $2x^2 + px + 24 = 0$ has two real roots in the ratio $1 : 3$. Find the value of p^2.

A 256

B 128

C 512

D 64

E 192

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Question 3

Find the minimum value of $|x-1|+|x-2|+|x-3|+|x-4|$ over all real x.

A 2

B 3

C 4

D 5

E 6

F 8

G 10

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Question 4

Find the sum of all real values of z for which there exist positive real numbers x and y satisfying the simultaneous equations

$$\log_2(x^2yz) = 3, \qquad \log_2(xz) = 1, \qquad (\log_2 y)(\log_2 z) = 2.$$

A 3

B $\frac{9}{4}$

C $\frac{9}{2}$

D 7

E 8

F 9

G $\frac{63}{4}$

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Question 5

Find the area of the region enclosed between the curves $y = 2|x - 1|$ and $y = 6 - |x + 2|$.

A $\frac{11}{2}$

B $\frac{20}{3}$

C $\frac{17}{3}$

D 6

E $\frac{13}{2}$

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Question 6

Given

$$g(x) = \frac{3}{4}\left(\sin\left(\frac{3}{2}x + \frac{\pi}{6}\right) + \cos\left(\frac{\pi}{3} - \frac{3}{2}x\right) + 2\right),$$

find the product of the maximum and minimum value of

$$4g(x) - (g(x))^2 - 3.$$

A -3

B 0

C 1

D 3

E 2

F -1

G 6

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Question 7

Find the product of all distinct values of p for which

$$(x-p)(x^2+px+p)=0$$

is satisfied by exactly two distinct values of x?

A 0

B -2

C $\frac{7}{2}$

D -4

E $-\frac{7}{2}$

F 2

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Question 8

Let a, b and c be positive integers satisfying

$$18^{a+c}6^{a+b+5} = 12^{b-2}18^{5}6^{c+2}.$$

Find the value of $a + b + c$.

A 5

B 6

C 7

D 8

E 9

F 10

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Question 9

The circles C_1 and C_2 have equations

$$x^2 + y^2 - 8y - 64 = 0 \quad \text{and} \quad x^2 + y^2 - 6x - 11 = 0.$$

A **common external tangent** is a line which touches both circles, with the two circles lying on the same side of the line. The two common external tangents to C_1 and C_2 meet at P. One of these common external tangents has equation $y = 2x - 16$. Let A be the centre of C_1 and let B be the centre of C_2. Find the value of AP.

A 12

B 10

C 15

D $3\sqrt{5}$

E $4\sqrt{5}$

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Question 10

The function

$$f(x) = \frac{1}{4}x^{4/3} + \sqrt[3]{x} + \frac{3}{\sqrt[3]{x^2}}$$

is defined for all real $x \neq 0$. In this question, f is said to be increasing on those parts of its domain where $f'(x) \geq 0$. What is the complete set of values of x for which f is increasing?

A $-3 \leq x < 0,\ x \geq 2$

B $x \leq -3,\ 0 < x \leq 2$

C $x \geq 2$

D $-3 < x < 0,\ x > 2$

E $-3 \leq x \leq 2,\ x \neq 0$

F $-3 \leq x \leq 0,\ x \geq 2$

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Question 11

In the expansion of $(a+bx)^7$, the coefficient of x^5 plus twice the coefficient of x^4 is the same as five times the coefficient of x^3. Given that a and b are positive integers, find the smallest possible value of ab.

A 3

B 5

C 6

D 10

E 15

F 16

G 9

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Question 12

The sum to infinity of a geometric sequence (u_n) is $\sqrt{3}$, and the sum to infinity of the sequence obtained by squaring each term of (u_n) is $\sqrt{6}$.

Define a new sequence (v_n) by

$$v_n = (-1)^{n+1}u_n$$

for all integers $n \geq 1$.

What is the sum to infinity of (v_n)?

A $\sqrt{3}$

B $\dfrac{2\sqrt{2}}{3}$

C $\sqrt{2}$

D infinity

E $\dfrac{\sqrt{3}}{2}$

F $\dfrac{\sqrt{2}}{2}$

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Question 13

Find the set of values of a for which the equation

$$x^4 - 4ax^3 + 4a^2x^2 - a = 0$$

has exactly 4 distinct real solutions.

A $a > 1$

B $|a| > 2$

C $a > 2$

D $a > \frac{1}{2}$

E $a > \frac{3}{2}$

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Question 14

The following sequence of transformations is applied, in the order listed, to the curve $y = 2x^2 - 3x + 1$.

(1) translation by $\begin{pmatrix} -1 \\ 4 \end{pmatrix}$;

(2) reflection in the line $y = 2$;

(3) stretch parallel to the x-axis with scale factor $\frac{1}{2}$.

What is the equation of the resulting curve?

A $y = -8x^2 - 2x$

B $y = -8x^2 + 2x$

C $y = -2x^2 - x$

D $y = -\frac{1}{2}x^2 - x$

E $y = -\frac{1}{2}x^2 + x$

F $y = -8x^2 - 4x$

G $y = 8x^2 + 2x$

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Question 15

Find the sum of the solutions of the equation

$$\sqrt{1-\sin^2 x} = 2\sin^2 x - \cos x$$

where $0 \leq x \leq 360°$.

A $180°$

B $360°$

C $540°$

D $720°$

E $900°$

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Question 16

Find the maximum value of the function

$$\mathrm{f}(x) = \frac{1}{4^x + 4^{-x} - 2\left(2^x + 2^{-x}\right) + 8}.$$

A $\frac{1}{8}$

B $\frac{1}{6}$

C $\frac{1}{5}$

D $\frac{1}{4}$

E 5

F 6

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Question 17

Let $0 \leq x \leq 2\pi$. Find the total length of the intervals on which $\sin(7x) \geq \cos(14x)$.

A $\frac{\pi}{12}$

B $\frac{\pi}{6}$

C $\frac{\pi}{3}$

D $\frac{2\pi}{3}$

E $\frac{5\pi}{12}$

F $\frac{\pi}{2}$

G $\frac{7\pi}{12}$

H $\frac{4\pi}{3}$

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Question 18

A function f satisfies

$$\int_0^2 f(x+1)\,dx = 1, \qquad \int_0^2 f(2-x)\,dx = 2, \qquad \int_0^{3/2} f(2x)\,dx = 3.$$

Find the value of $\int_1^2 f(x)\,dx$.

A -6

B -3

C 0

D 1

E 3

F 4

G 5

H 6

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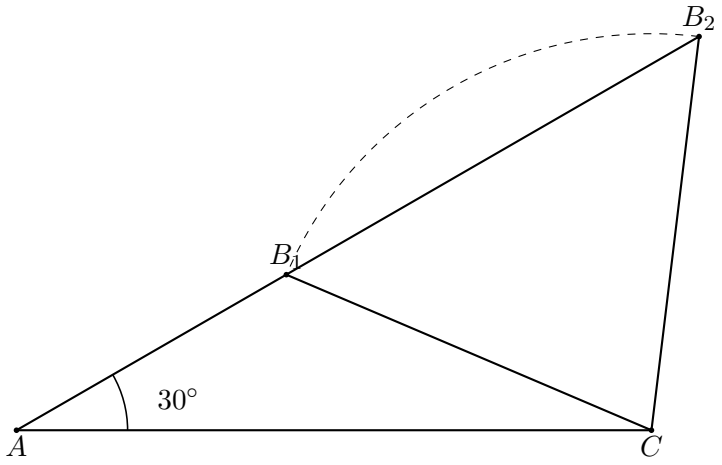
Question 19

In a triangle ABC the angle at vertex A is $30°$. The side BC has length $(x-2)(x-3)$ and the side AC has length $(3-x)(x-8)$. Find the complete set of values of x for which there are two non-congruent triangles.



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A $3 < x < 4$

B $3 < x < 5$

C $3 < x < 8$

D $4 < x < 5$

E $4 < x < 8$

F $5 < x < 8$

Question 20

A sequence of real numbers (a_n) is defined by $a_1 = 2$ and the recurrence

$$a_{n+1}(a_n - 1) = \frac{1}{2}a_n^2 - a_n + \frac{1}{2} \qquad (n \geq 1).$$

Find the value of

$$\sum_{n=1}^{\infty}(a_n + 1).$$

A 0

B 4

C $\frac{5}{2}$

D 6

E 8

F $\frac{9}{4}$

G $\frac{5}{4}$

H ∞

I $-\infty$

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