

HU Collection

Engineering and Science Admissions Test

Mock Set B

Mathematics 2

Time allowed: 40 minutes
Questions: 27 multiple choice
Calculators: not permitted
Written by: Kevin Hu
Date written: 27 October 2026

Name: Date sat: Score: / 27

Instructions

Answer all 27 questions. Each question has exactly one correct option and is worth one mark. No marks are deducted for wrong answers, so answer every question. Calculators are not permitted. This paper is deliberately longer than the time allows: move on from any question that is costing you more than two minutes, and come back to it at the end.

Q	1	2	3	4	5	6	7	8	9	10
Ans										

Q	11	12	13	14	15	16	17	18	19	20
Ans										

Q	21	22	23	24	25	26	27			
Ans										

1. A sealed mineral sample contains two radioactive isotopes, P and Q , neither of which is produced inside the sample. Isotope P has a half-life of 1200 years and isotope Q has a half-life of 1800 years. When the sample formed, it contained 8 times as many atoms of P as atoms of Q . Today it contains only one quarter as many atoms of P as atoms of Q . How many years ago did the sample form?

- A** 18 000 **B** 10 800 **C** 6000
D 9000 **E** 3600 **F** 3000

2. A rectangular frame has perimeter 40 dm. To fit into its packing crate, the length of its diagonal must be at most 15 dm, and for rigidity each of its sides must be at least 7 dm long. Which of the following describes all the possible values of the area A of the frame, in dm^2 ?

- A** $87.5 \leq A \leq 112.5$ **B** $91 \leq A \leq 100$ **C** $87.5 \leq A \leq 100$
D $49 \leq A \leq 100$ **E** $0 < A \leq 100$ **F** $91 \leq A \leq 112.5$

3. A ship sails in a straight line from a harbour H on a course that makes an angle of 30° with the line from H to a lighthouse L , where $HL = 10$ km. The ship's radar can detect the lighthouse only when the ship is within 7 km of it. The ship keeps to its course until it is far beyond the lighthouse. What is the total distance the ship sails while it is within 7 km of the lighthouse?

- A** $4\sqrt{6}$ km **B** $\sqrt{51}$ km **C** $(5\sqrt{3} + 2\sqrt{6})$ km
D $5\sqrt{3}$ km **E** $10\sqrt{3}$ km **F** $2\sqrt{6}$ km

4. A walkway runs along the x -axis from $x = 0$ to $x = 3$, with lengths in metres. Above it, the underside of a curved roof truss is modelled by

$$y = x^2 - 2kx + 4,$$

where k is a design constant. Safety rules require the truss to be strictly above the walkway at every point of it, that is, $y > 0$ for every x with $0 \leq x \leq 3$. Which of the following describes all the values of k that satisfy the rules?

- A** $k < \frac{13}{6}$ **B** $k < 2$ **C** $-2 < k < \frac{13}{6}$
D $0 < k < 2$ **E** $-2 < k < 2$ **F** $k \leq 2$

5. Two arithmetic progressions are described by their partial sums. For every positive integer n , the sum of the first n terms of the first progression is $3n^2 + 4n$, and the sum of the first n terms of the second progression is $5n^2 - 2n$. How many numbers less than 1000 are terms of both progressions?

- A** 32 **B** 33 **C** 16
D 1 **E** 66 **F** 34

6. A cargo ship is to make a journey of 300 km at a constant speed of v km/h, where harbour regulations require $0 < v \leq 15$. While the ship is moving, its running cost is

$$\left(\frac{v^3}{1000} + 16 \right) \text{ hundred pounds per hour.}$$

What is the least possible running cost of the whole journey, in hundreds of pounds?

- A** 400 **B** 375 **C** 320
D 360 **E** 387.5 **F** 510

7. The line $y = 2x + c$, where c is an integer, meets the circle

$$x^2 + y^2 - 6x + 4y - 12 = 0$$

at two points A and B . Given that the chord AB has length at least 6, what is the sum of all the possible values of c ?

- | | | |
|---------------|---------------|---------------|
| A 104 | B -152 | C 136 |
| D -136 | E -104 | F -120 |

8. A long horizontal pipe has a circular internal cross-section of radius 2 m. Water flows along the pipe, and in every cross-section the water is 3 m deep at its deepest point. Engineers define the *hydraulic radius* of the flow as the cross-sectional area of the water divided by the wetted perimeter, where the wetted perimeter is the length of the part of the pipe's internal boundary, in the cross-section, that is in contact with the water. What is the hydraulic radius, in metres?

- | | | |
|---------------------------------------|--|---------------------------------------|
| A $1 + \frac{3\sqrt{3}}{4\pi}$ | B $\frac{8\pi + 3\sqrt{3}}{8\pi + 6\sqrt{3}}$ | C $1 - \frac{3\sqrt{3}}{4\pi}$ |
| D $1 + \frac{3\sqrt{3}}{8\pi}$ | E $1 + \frac{3}{8\pi}$ | F 1 |

9. A circular running track passes through three marker posts with coordinates $A(1, 3)$, $B(13, 9)$ and $C(7, 1)$, in units of 10 m. A straight footpath runs from a gate at the origin O and meets the track at a single point T , touching it there. What is the length OT , in the same units?

- | | | |
|----------------------|---------------------------|----------------------|
| A 5 | B $5\sqrt{6}$ | C 10 |
| D $\sqrt{10}$ | E $10 - 5\sqrt{2}$ | F $5\sqrt{2}$ |

10. What is the largest integer that is less than $(\sqrt{2} + \sqrt{3})^6$?

- | | | |
|--------------|--------------|--------------|
| A 969 | B 968 | C 485 |
| D 970 | E 971 | F 484 |

11. Positive real numbers x and y , with $x \neq y$, satisfy

$$x^y = y^x \quad \text{and} \quad y^2 = x^3.$$

What is the value of $x + y$?

- | | | |
|--------------------------|--------------------------|-------------------------|
| A $\frac{45}{8}$ | B $\frac{81}{16}$ | C $\frac{27}{4}$ |
| D $\frac{20}{27}$ | E 2 | F $\frac{13}{4}$ |

12. A cup of coffee cools in a room whose temperature stays constant but is not known. Assume Newton's model: the excess of the coffee's temperature over the room temperature is multiplied by the same factor in any two time intervals of equal length. A thermometer in the coffee reads 92°C at 09:00, 56°C at 09:10 and 38°C at 09:20. According to the model, at what time will the thermometer read 22.25°C ?

- | | | |
|----------------|----------------|----------------|
| A 10:00 | B 10:10 | C 09:40 |
| D 09:45 | E 09:50 | F 09:30 |

13. How many values of x in the interval $0 \leq x < 2\pi$ satisfy

$$9^{\sin^2 x} + 9^{\cos^2 x} = 4\sqrt{3}?$$

- A** 8 **B** 4 **C** 6
D 0 **E** 16 **F** 2

14. For which real values of m does the equation

$$\sqrt{x+4} = mx + 2$$

have exactly two distinct real solutions?

- A** $0 < m < \frac{1}{2}$ with $m \neq \frac{1}{4}$ **B** $0 < m \leq \frac{1}{2}$ with $m \neq \frac{1}{4}$ **C** $m \neq 0$ with $m \neq \frac{1}{4}$
D $0 < m < \frac{1}{4}$ **E** $\frac{1}{4} < m \leq \frac{1}{2}$ **F** $m > 0$ with $m \neq \frac{1}{4}$

15. The boundary of a circular arena is the circle

$$x^2 + y^2 - 4x + 2y - 20 = 0.$$

A floodlight stands at the point $P(4, 1)$. Every straight chord of the boundary circle that passes through P is considered. The midpoints of all these chords form a closed curve. What is the area enclosed by this curve?

- A** π **B** 2π **C** 4π
D 8π **E** 25π **F** $\frac{\pi}{2}$

16. The volume V , in thousands of cubic metres, of water in a reservoir t hours after midnight satisfies

$$\frac{dV}{dt} = 6\sqrt{t} - t - 8 \quad \text{for } 0 \leq t \leq 25.$$

At midnight the reservoir holds 100 thousand cubic metres. What is the least volume of water in the reservoir, in thousands of cubic metres, at any time in this 25-hour period?

- A** 95.5 **B** 88 **C** 100
D 87.5 **E** 90 **F** 92

17. Two vertical walls meet at a corner, making an angle of 60° with each other. Infinitely many circular discs lie flat on the floor in the corner. Each disc touches both walls; the first disc has radius 9 cm, and each subsequent disc touches the previous one and lies between it and the corner. What is the total area of all the discs, in cm^2 ?

- A** 81π **B** $\frac{729\pi}{8}$ **C** $\frac{729\pi}{10}$
D 27π **E** 108π **F** $\frac{243\pi}{2}$

18. A taut drive belt passes around two pulleys of radii 9 cm and 3 cm, whose centres are 24 cm apart. The belt crosses over itself between the pulleys: its two straight sections are both tangent to both pulleys, and they cross each other on the line joining the centres. Ignoring the thickness of the belt, what is its total length, in cm?

- A** $24\sqrt{3} + 12\pi$ **B** $24\sqrt{3} + 8\pi$ **C** $12\sqrt{3} + 16\pi$
D $12\sqrt{15} + 16\pi$ **E** $48 + 16\pi$ **F** $24\sqrt{3} + 16\pi$

19. A paper drinking cup in the shape of an open right circular cone is made by cutting a sector from a circular sheet of radius 6 cm and joining the two straight edges of the sector exactly, without overlap. What sector angle, in radians, gives the cup of greatest capacity?

- A** π **B** $\pi\sqrt{2}$ **C** $\frac{\pi\sqrt{6}}{3}$
D $\frac{2\pi\sqrt{3}}{3}$ **E** $\frac{2\pi\sqrt{6}}{3}$ **F** $\frac{4\pi}{3}$

20. On a flat practice pitch, the two goalposts stand at points A and B that are 4 m apart, and the goal line is the straight line through A and B . For a point P on the pitch side of the goal line (not on the line itself), the angle APB is called the shooting angle at P . What is the area, in m^2 , of the region of the pitch from which the shooting angle is at least 45° ?

- A** $12\pi + 8$ **B** 8π **C** $6\pi + 4$
D 6π **E** $6\pi - 4$ **F** $2\pi - 4$

21. Let $f(x) = x^{2/3}(x - 5)$ for all real x , where $x^{2/3}$ means $(\sqrt[3]{x})^2$, using the real cube root. Which of the following statements are true?

- I. f has a local maximum at $x = 0$.
 II. f is decreasing for every $x < 2$.
 III. The equation $f(x) = -4$ has exactly three real solutions.
- A** none of them
B II and III only
C III only
D I, II and III
E II only
F I and III only
G I and II only
H I only

22. A window has the shape of the region bounded by the x -axis and the parabola $y = 4 - x^2$, with lengths in metres. A straight horizontal glazing bar is fitted along the line $y = h$, dividing the glass into two parts of equal area. What is the value of h ?

- A** $2\sqrt[3]{2}$ **B** $4 - \sqrt[3]{4}$ **C** 2
D $4 - 2\sqrt{2}$ **E** $4 - \sqrt[3]{2}$ **F** $4 - 2\sqrt[3]{2}$

23. A cubic polynomial function f has a local maximum at the point $(1, 4)$ and a local minimum at the point $(3, 0)$. Consider the following six equations.

- I. $f(|x|) = 1$

- II. $|f(x)| = 1$
- III. $|f(|x|)| = 3$
- IV. $f(|x|) = 4$
- V. $|f(x)| = 4$
- VI. $f(|x|) = 0$

For how many of these equations is the number of distinct real solutions exactly four?

- A 0
- B 6
- C 3
- D 2
- E 1
- F 5
- G 4

24. A cable hangs between the tops of two vertical poles that stand 4 m apart on level ground. Taking the foot of one pole as the origin, the height of the cable above the ground at horizontal distance x m is $f(x)$ m, where f is known to be a polynomial of degree at most 3. An assistant measured the heights at equally spaced points and applied the trapezium rule to estimate

$$\int_0^4 f(x) dx,$$

obtaining 20 with 2 strips and 18.5 with 4 strips, and then lost the measurements. What is the exact value of $\int_0^4 f(x) dx$?

- | | | |
|------|---------|---------|
| A 17 | B 17.75 | C 19.25 |
| D 18 | E 18.5 | F 18.25 |

25. A particle moves along a straight line. At time t seconds its velocity is v m/s, where v is a cubic polynomial in t whose t^3 coefficient is 4. The particle is at a point O when $t = 0$, and it is back at O when $t = 1$, when $t = 2$ and when $t = 3$. What is the greatest distance of the particle from O , in metres, during the interval $0 \leq t \leq 3$?

- | | | |
|-----------------|------------------|-------------------|
| A 2 | B 1 | C $\frac{1}{2}$ |
| D $\frac{3}{4}$ | E $\frac{9}{16}$ | F $\frac{25}{16}$ |

26. The profile of a curved track is the curve

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

A straight rod is placed against the track so that it is tangent to the curve at two distinct points. What is the distance between these two points of contact?

- | | | |
|----------------|----------------|---------------|
| A $2\sqrt{15}$ | B $2\sqrt{6}$ | C $\sqrt{15}$ |
| D $\sqrt{6}$ | E $3\sqrt{10}$ | F $\sqrt{30}$ |

27. A tower is built from 10 000 thin layers stacked one on top of another. For each $k = 1, 2, \dots, 10\,000$, the k th layer from the bottom has thickness $\frac{1}{\sqrt{k}}$ cm. What is the height of the tower, correct to the nearest centimetre?

A 201 cm

B 198 cm

C 100 cm

D 197 cm

E 200 cm

F 199 cm



End of paper