

Mathematics, 2017 EC, entrance exam, version 1

Grade 12 · Mathematics · 2017 E.C.

MARKING KEY: CONFIDENTIAL

Time allowed: 120 minutes

Questions: 42

Total marks: 42

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1. Which one of the following defines prime number? (1)
- A. It is a natural number that has an odd number of factors
 - B. It is an odd natural number that has only two factors
 - C. ✓ It is a natural number that has exactly two distinct factors
 - D. It is a natural number where one of its factors is 3

Answer: C

A prime number is a natural number with exactly two different factors, 1 and the number itself. That is the reason 1 is not prime: it has only one factor. Option B is tempting because most primes are odd, but 2 is prime and even, so "odd" cannot belong in the definition.

2. The GCF of two numbers is 9 and their LCM is 54. If one of the numbers is 18. What is the other number? (1)
- A. 36
 - B. 54
 - C. ✓ 27
 - D. 72

Answer: C

For any two whole numbers, GCF times LCM equals the product of the numbers. So the missing number is $\frac{9 \times 54}{18} = \frac{486}{18} = 27$. Check it: the greatest common factor of 18 and 27 is 9, and their least common multiple is 54. Option B, 54, is tempting because that number already appears in the question, but 54 is the LCM, not the second number.

3. If $x = 0.424424442\dots$ and $y = 0.242242224\dots$ then the fraction form of $x + y$ is equal to (1)
- A. $\frac{6}{10}$
 - B. $\frac{3}{4}$
 - C. ✓ $\frac{2}{3}$
 - D. $\frac{4}{5}$

Answer: C

Neither decimal repeats, but their digits pair up. Wherever x has a 4, y has a 2, and wherever x has a 2, y has a 4. Every digit of the sum is therefore 6, so $x + y = 0.6666\dots$, and $0.\overline{6} = \frac{2}{3}$. Option A, $\frac{6}{10}$, is what you get by stopping after one digit, but the sixes carry on forever.

4. For any real numbers a , b and c . Which one of the following is true? (1)
- A. If $a < b$ then $a^2 < b^2$
 - B. If $a < b$ then $ac < bc$
 - C. If $a^2 < b^2$ then $b < a$
 - D. ✓ If $a < b$ and $b < c$ then $c > a$

Answer: D

Option D is the transitive property of order: if $a < b$ and $b < c$, then $a < c$, which is the same as saying $c > a$. It holds for every choice of real numbers. Option B looks safe, but multiplying an inequality by a negative number flips it: $2 < 3$ while $2(-1) > 3(-1)$.

A system of two linear equations has no solution when the lines are parallel: the same ratio between the x and y coefficients, but different constants. Matching them, $\frac{4}{2} = \frac{-8}{k}$ gives $2k = -8$, so $k = -4$. Check the constants: doubling $2x - 4y = 16$ gives $4x - 8y = 32$, which can never agree with -3 , so the system really is impossible. Option C, $k \neq -4$, makes the lines cross, which gives one solution instead of none.

10. If one root of the quadratic equation $x^2 - x + m = 0$ exceeds the other by 5. What is the value of m ? (1)

- A. ✓ -6
B. 6
C. 5/2
D. -3/2

Answer: A

For $x^2 - x + m = 0$ the roots add to 1 and multiply to m . Call them r and $r + 5$. Then $2r + 5 = 1$, so $r = -2$ and the second root is 3. Their product is $(-2)(3) = -6$, so $m = -6$. Option B, 6, comes from forgetting that one of the roots is negative.

11. Let $A = \{1, 2, \{3, 4\}, 5\}$ be a set. Which of the following is not true? (1)

- A. $\{\{3, 4\}\} \subseteq A$
B. ✓ $\{4\} \in A$
C. $\emptyset \subseteq A$
D. $\{1, 2, 5\} \subset A$

Answer: B

The elements of A are 1, 2, $\{3, 4\}$ and 5. The set $\{4\}$ is not one of them, so $\{4\} \in A$ is false, and a false statement is what the question asks for. Option A is the tempting one, but $\{\{3, 4\}\}$ is a set whose only element is $\{3, 4\}$, and $\{3, 4\}$ genuinely sits inside A , so that subset claim is true.

12. Let $A = \{x: x^2 - 4 = 0\}$ and $B = \{x: x \text{ is a positive factor of } 4\}$. Which one of the following is $B \setminus A$? (1)

- A. ✓ $\{1, 4\}$
B. $\{2, 4\}$
C. $\{1, 2, 4\}$
D. $\{2\}$

Answer: A

Solving $x^2 - 4 = 0$ gives $A = \{-2, 2\}$. The positive factors of 4 are $B = \{1, 2, 4\}$. The difference $B \setminus A$ keeps whatever is in B but not in A , and only 2 is shared, so what remains is $\{1, 4\}$. Option C, $\{1, 2, 4\}$, is all of B , which forgets to take the shared 2 out.

13. For any two non empty sets A and B if $A \subset B$, then which one of the following is always true? (1)

- A. $A \cap B = B$
B. $A \cup B = A$
C. $A \Delta B = A \cup B$
D. ✓ $(A \cup B) \cap A = A$

Answer: D

If $A \subset B$, every element of A already lies in B , so $A \cup B = B$ and $B \cap A = A$. Option D chains those two facts: $(A \cup B) \cap A = B \cap A = A$, which is always true. Option A is the trap, because $A \cap B$ keeps only what the two sets share, and that is A , not B .

14. In a class of 52 students 34 passed in Mathematics and 28 passed in English. If the number of students who failed in both subjects is 9. What is the number of students who passed in both subjects? (1)

- A. ✓ 19
B. 10
C. 9
D. 6

Answer: A

If 9 students failed both subjects, then $52 - 9 = 43$ passed at least one of them. For two overlapping groups, the number in both is found from $n(M) + n(E) - n(M \cup E)$, which gives $34 + 28 - 43 = 19$. Option B, 10, comes from subtracting the 9 failures from a count of the overlap instead of working from the class total.

15. Which one of the following is the range of the function $f(x) = (2x+3)/(x-1)$? (1)

- A. $\mathbb{R} \setminus \{1\}$ B. $\mathbb{R} \setminus \{3\}$
C. ✓ $\mathbb{R} \setminus \{2\}$ D. $\mathbb{R}$

Answer: C

Make x the subject. From $y = \frac{2x+3}{x-1}$ we get $y(x-1) = 2x+3$, so $yx - 2x = y + 3$ and $x = \frac{y+3}{y-2}$. Every value of y comes from some x except $y = 2$, which would divide by zero, so the range is $\mathbb{R} \setminus \{2\}$. Option A, $\mathbb{R} \setminus \{1\}$, is the domain of f , because $x = 1$ is the value the formula cannot take.

16. Which one of the following is true about the function $f(x) = 3x^{4/5}$? (1)

- A. The domain of f is $\mathbb{R} \setminus \{0\}$ B. ✓ The range of f is $[0, \infty)$
C. f is increasing on $(-\infty, 0]$ D. f is decreasing on $[0, \infty)$

Answer: B

Write $f(x) = 3x^{4/5} = 3(\sqrt[5]{x})^4$. A fifth root exists for every real number, and raising it to an even power can never give a negative result. So $f(x) \geq 0$ for all x , with $f(0) = 0$ and values rising without bound, which makes the range $[0, \infty)$. Option A is tempting because fractional powers often shut out 0, but the fifth root of 0 is fine, so the domain is all of $\mathbb{R}$.

17. What is the solution set of the equation $\text{sgn}(x^2-1) = -1$? (1)

- A. $[-1, 1]$ B. ✓ $(-1, 1)$
C. $(-\infty, -1] \cup [1, \infty)$ D. $(-\infty, -1) \cup (1, \infty)$

Answer: B

The signum function returns -1 exactly when its input is negative. So the equation asks for $x^2 - 1 < 0$, that is $x^2 < 1$, which holds for $-1 < x < 1$. Option A, $[-1, 1]$, is the trap: at $x = \pm 1$ the input becomes 0, and $\text{sgn}(0) = 0$, not -1 , so the two endpoints must be left out.

18. Which one of the following is the solution set of the equation $1/(x-2) + 6x/(x^2-4) = 3/(x+2)$? (1)

- A. $\{-4, 2\}$ B. $\{-2\}$
C. $\{-1, 1\}$ D. ✓ $\emptyset$

Answer: D

Because $x^2 - 4 = (x-2)(x+2)$, multiply every term by $(x-2)(x+2)$. That gives $(x+2) + 6x = 3(x-2)$, so $7x + 2 = 3x - 6$, then $4x = -8$ and $x = -2$. But $x = -2$ makes the original denominators zero, so it has to be thrown out and nothing survives. The solution set is empty. Option B, $\{-2\}$, is the trap: the algebra does produce that number, but the equation itself has no meaning there.

19. Which of the following is the solution of the rational inequality $(x^2-6x)/(x-12) > 1$? (1)

- A. $(3, 4)$ B. $(12, \infty)$
C. $(3, 4] \cup (12, \infty)$ D. ✓ $(3, 4) \cup (12, \infty)$

Answer: D

Move everything to one side: $\frac{x^2-6x}{x-12} - 1 > 0$ becomes $\frac{x^2-7x+12}{x-12} > 0$, that is $\frac{(x-3)(x-4)}{x-12} > 0$. The cut points are 3, 4 and 12. Testing a number inside each strip, the quotient is positive on $(3, 4)$ and on $(12, \infty)$. Option C is tempting, but at $x = 4$ the numerator is zero, so the quotient equals 0 and a strict inequality is not satisfied.

20. Which one of the following function does not have a vertical asymptote? (1)

A. ✓ $f(x)=3/(x^2+1)$

B. $f(x)=(x+1)/(x^2-1)$

C. $f(x)=(2x+3)/(x^3+1)$

D. $f(x)=1/x^2$

Answer: A

A vertical asymptote appears where the denominator is zero while the numerator is not. For $f(x) = \frac{3}{x^2+1}$ we have $x^2 + 1 \geq 1$ for every real x , so the denominator never reaches zero and no vertical asymptote can form. Option B is tempting because $x^2 - 1 = 0$ at $x = \pm 1$, but only $x = -1$ cancels against the numerator, and $x = 1$ still produces a vertical asymptote.

21. In a class there are 8 more boys than girls. If the ratio of boys to girls is 4 to 3. What is the number of girls in the class? (1)

A. 32

B. ✓ 24

C. 22

D. 30

Answer: B

Let g be the number of girls. Then the boys number $g + 8$, and the given ratio says $\frac{g+8}{g} = \frac{4}{3}$. Cross multiplying, $3(g + 8) = 4g$, so $3g + 24 = 4g$ and $g = 24$. Check it: 32 boys and 24 girls differ by 8 and are in the ratio 4 : 3. Option A, 32, is the number of boys, which the question did not ask for.

22. Let $A = [[3, a+b], [2, 4]]$ and $B = [[8, 6], [2, a-b]]$. If $A = B$, then the value of a is: (1)

A. 2

B. 3

C. 4

D. ✓ 5

Answer: D

Two matrices are equal when every matching position holds the same number. The position carrying $a + b$ must equal 6, and the position carrying $a - b$ must equal 4. Adding those two equations removes b and gives $2a = 10$, so $a = 5$, with $b = 1$. Option B, 3, is tempting because a 3 is printed inside the matrix, but that is an entry, not the value of a .

23. Which one of the following matrix has no equal number of rows and columns? (1)

A. Square matrix

B. ✓ Rectangular matrix

C. Diagonal matrix

D. Identity matrix

Answer: B

A square matrix has the same number of rows as columns by definition, and both the diagonal matrix and the identity matrix are square, so their counts always match. Only a rectangular matrix is free to have a different number of rows and columns, for example a 2×3 array. Option C is tempting because a diagonal sounds like a line you could draw across any shape, but a main diagonal is defined only for a square array.

24. What is the solution of the system $\{x+y=5, 2x-y=1\}$? (1)

A. (3,2)

B. (1,4)

C. (4,1)

D. ✓ (2,3)

Answer: D

Add the two equations so that y cancels: $(x + y) + (2x - y) = 5 + 1$ gives $3x = 6$, so $x = 2$. Then $y = 5 - 2 = 3$, and the solution is $(2, 3)$. Option A, $(3, 2)$, is the same pair in the wrong order: it satisfies $x + y = 5$, but $2(3) - 2 = 4$, not 1.

The multiples of 15 between 1 and 100 are 15, 30, 45, 60, 75 and 90. Take the 15 out as a common factor: the sum is $15(1 + 2 + 3 + 4 + 5 + 6) = 15 \times 21 = 315$. Option C, 300, is exactly what you get if you begin the list at 30 and forget that 15 itself belongs on it.

31. The sum of series $1 - 1/2 + 1/4 - 1/8 + \dots$ is equal to:

(1)

- A. $3/2$ B. $1/2$
C. ✓ $2/3$ D. 2

Answer: C

This is an infinite geometric series with first term $a = 1$ and common ratio $r = -\frac{1}{2}$. Since $|r| < 1$ the series converges, and the sum is $\frac{a}{1-r} = \frac{1}{1+\frac{1}{2}} = \frac{1}{\frac{3}{2}} = \frac{2}{3}$. Option D, 2, is what you get if you drop the minus sign and treat the series as $1 + \frac{1}{2} + \frac{1}{4} + \dots$.

32. Which one of the following is a convergent sequence?

(1)

- A. $\{(5/3)^n\}$ B. ✓ $\{3n/(n+1)\}$
C. $\{n^2/(2n+1)\}$ D. $\{(1/n)^{-1}\}$

Answer: B

A sequence converges when its terms settle towards a single number. Divide the top and bottom by n : $\frac{3n}{n+1} = \frac{3}{1+\frac{1}{n}}$, and as n grows $\frac{1}{n}$ shrinks to 0, so the terms approach 3. Option C is tempting because it is also a fraction, but $\frac{n^2}{2n+1}$ behaves like $\frac{n}{2}$ for large n and keeps growing, so it diverges.

33. A man accepts a position with initial salary of Birr 12500 per year, increasing by Birr 250 each year. What will be his salary at the beginning of 12th year?

(1)

- A. 14,750 B. 15,000
C. ✓ 15,250 D. 14,500

Answer: C

The yearly salaries form an arithmetic sequence with first term 12,500 and common difference 250. At the start of the 12th year he has received 11 increases, so the salary is $12,500 + 11(250) = 12,500 + 2,750 = 15,250$ birr. Option A, 14,750, counts only 9 increases, which lands on the 10th year instead.

34. Which of the following is the average rate of change of $f(x)=x^3-2x$ on $[1,3]$?

(1)

- A. 10 B. -10
C. ✓ 11 D. -11

Answer: C

The average rate of change on $[1, 3]$ is $\frac{f(3)-f(1)}{3-1}$. Here $f(3) = 27 - 6 = 21$ and $f(1) = 1 - 2 = -1$, so the rate is $\frac{21-(-1)}{2} = \frac{22}{2} = 11$. Option A, 10, is what you get by taking $f(1) = 1$ and forgetting the $-2x$ term.

35. Let $f(x)=\pi^2-3$, then $f'(2)$ is equal to:

(1)

- A. 2π B. 4
C. -1 D. ✓ 0

Answer: D

Both π^2 and 3 are fixed numbers, so $f(x) = \pi^2 - 3$ is a constant function. Its graph is a horizontal line, and the derivative of a constant is 0 at every point, so $f'(2) = 0$. Option A, 2π , is the trap: π looks like a variable because it is a letter, but it is a fixed number close to 3.14, and there is no x in the formula at all.

36. Let $f(x)=kx^2-2x+1$ and $f'(2)=10$, then what is k ? (1)
- A. 2
B. ✓ 3
C. 4
D. 5

Answer: B

Differentiate term by term: $f'(x) = 2kx - 2$. Putting $x = 2$ gives $f'(2) = 4k - 2$, and setting that equal to 10 gives $4k = 12$, so $k = 3$. Option A, 2, follows from a sign slip: reading the derivative of $-2x$ as $+2$ turns the equation into $4k + 2 = 10$.

37. If $f'(1)=5$, $f(1)=4$ and $g'(4)=5$, then $(g \circ f)'(1)$ is: (1)
- A. 20
B. ✓ 25
C. 15
D. 30

Answer: B

This is the chain rule: $(g \circ f)'(x) = g'(f(x)) \cdot f'(x)$. At $x = 1$ the inner value is $f(1) = 4$, so the outer derivative is taken at 4. That gives $(g \circ f)'(1) = g'(4) \cdot f'(1) = 5 \times 5 = 25$. Option A, 20, comes from multiplying by $f(1) = 4$ instead of using it as the input to g' .

38. What is the absolute minimum value of $f(x)=x^2+2x$ on $[-2,2]$? (1)
- A. -3
B. 8
C. 0
D. ✓ -1

Answer: D

The graph of $f(x) = x^2 + 2x$ is a parabola opening upward, and its vertex sits at $x = -\frac{b}{2a} = -\frac{2}{2} = -1$, which lies inside $[-2, 2]$. There $f(-1) = 1 - 2 = -1$. The endpoints give $f(-2) = 0$ and $f(2) = 8$, both larger, so the absolute minimum is -1 . Option C, 0, is the endpoint value at $x = -2$, and it wins only if you skip checking the vertex.

39. Which one of the following is the equation of tangent line to $f(x)=3x^2+4x-5$ at $(0,-5)$? (1)
- A. ✓ $y=4x-5$
B. $y=4x+5$
C. $y=-4x-5$
D. $y=-4x+5$

Answer: A

The slope of the tangent at a point is the derivative there. Here $f'(x) = 6x + 4$, so $f'(0) = 4$. Using $y - y_1 = m(x - x_1)$ with the point $(0, -5)$ gives $y + 5 = 4x$, that is $y = 4x - 5$. Option B, $y = 4x + 5$, has the correct slope but misses the point: at $x = 0$ it passes through 5, not -5 .

40. The volume of spherical balloon is increasing at rate $24 \text{ cm}^3/\text{sec}$. What is rate of change of surface area when radius=8 cm? (1)
- A. ✓ $6 \text{ cm}^2/\text{sec}$
B. $8 \text{ cm}^2/\text{sec}$
C. $4 \text{ cm}^2/\text{sec}$
D. $3 \text{ cm}^2/\text{sec}$

Answer: A

For a sphere $V = \frac{4}{3}\pi r^3$, so $\frac{dV}{dt} = 4\pi r^2 \frac{dr}{dt}$. With $\frac{dV}{dt} = 24$ and $r = 8$, $\frac{dr}{dt} = \frac{24}{4\pi(64)} = \frac{3}{32\pi}$. The surface area is $S = 4\pi r^2$, so $\frac{dS}{dt} = 8\pi r \frac{dr}{dt} = 8\pi(8) \left(\frac{3}{32\pi}\right) = 6 \text{ cm}^2/\text{sec}$. Option D, 3, is what you get by using $4\pi r$ in place of $8\pi r$ when differentiating $4\pi r^2$.

41. What is interquartile range (IQR) in statistics?

(1)

- A. Difference between mean and median
- B. ✓ **Difference between 3rd quartile and 1st quartile**
- C. Difference between maximum and minimum
- D. Half of difference between 3rd and 1st quartile

Answer: B

The quartiles cut an ordered set of data into four equal parts. The interquartile range describes how spread out the middle half is, so it is the third quartile minus the first, $Q_3 - Q_1$. Option D is tempting because half of that difference also has a name, the quartile deviation, but the IQR itself is the full difference, not half of it.

42. What is the mean deviation from the mean for data: 5,3,7,8,4,9?

(1)

- | | |
|---------------|------|
| A. ✓ 2 | B. 4 |
| C. 3 | D. 0 |

Answer: A

First find the mean: $\frac{5+3+7+8+4+9}{6} = \frac{36}{6} = 6$. Now measure how far each value sits from 6, ignoring the sign: 1, 3, 1, 2, 2, 3, which add up to 12. The mean deviation is $\frac{12}{6} = 2$. Option D, 0, is what you get if you keep the signs, because deviations above and below the mean always cancel out. That cancelling is the reason the absolute value is taken.

END OF THE MARKING KEY

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