

Mathematics, 2016 EC, social science, entrance exam, round 1

Grade 12 · Mathematics · 2016 E.C.

MARKING KEY: CONFIDENTIAL

Time allowed: 120 minutes

Questions: 38

Total marks: 38

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1. In the set of natural numbers, which one of the following defines a composite number? (1)

- A. A number that has only two distinct factors.
- B. A number that is divisible by numbers from 2 to 9.
- C. A number that has two or more different factors.
- D. ✓ **A number that has three or more different divisors.**

Answer: D

A composite number is defined as a natural number greater than 1 that has more than two distinct positive divisors, meaning it must have three or more different divisors.

2. Which of the following is true about rationalizing the denominator? (1)

- A. Only denominators can be multiplied by an irrational number.
- B. Only numerators can be rationalized when there is a radical.
- C. ✓ **It is a method of changing the denominator into a rational number.**
- D. It is a technique of multiplying a given number by an irrational expression.

Answer: C

Rationalizing the denominator refers to the algebraic process of multiplying the numerator and denominator by an appropriate radical expression to eliminate any radicals from the denominator, converting it to a rational number.

3. Which one of the following refers to the definition of similar plane figures? (1)

- A. Figures whose corresponding angles have the same ratio.
- B. ✓ **Figures where one is an enlargement of the other.**
- C. Figures whose ratios of length of corresponding sides are different.
- D. Figures that have different shapes but might have same size.

Answer: B

By definition, two plane figures are similar if they have the exact same shape but not necessarily the same size, meaning one is a scaled enlargement (or reduction) of the other.

4. In $\triangle ABC$ $m(\angle B) = 90^\circ$, with $m(\angle A) = 30^\circ$ and $BC = 11\text{cm}$, then what is the length of $\overline{AC}$? (1)

A. ✓ 22 cm

B. $\frac{22\sqrt{3}}{3}\text{cm}$

C. $11\sqrt{3}\text{ cm}$

D. $\frac{11\sqrt{3}}{3}\text{cm}$

Answer: A

Since $m(\angle B) = 90^\circ$, the triangle is right-angled with hypotenuse AC . Using the sine ratio for $\angle A$, we have $\sin(30^\circ) = \frac{BC}{AC}$, which simplifies to $\frac{1}{2} = \frac{11}{AC}$ and gives $AC = 22\text{ cm}$.

5. Given a circle of diameter 16 cm, a chord of the circle is 6 cm far from the center of the circle. Which of the following is the length of the chord? (1)

A. $2\sqrt{7}\text{ cm}$

B. 8 cm

C. ✓ $4\sqrt{7}\text{ cm}$

D. 16 cm

Answer: C

Since the diameter is 16 cm, the radius is 8 cm. Using the Pythagorean theorem, the half-chord length is $\sqrt{8^2 - 6^2} = \sqrt{28} = 2\sqrt{7}\text{ cm}$, making the full chord length $4\sqrt{7}\text{ cm}$.

6. Let $\bar{x}$ denote the arithmetic mean of a numerical data. If each observation is multiplied by 0.5, which of the following is the new mean? (1)

A. $\bar{x}$

B. ✓ $\frac{1}{2}\bar{x}$

C. $2\bar{x}$

D. $\bar{x} - 0.5$

Answer: B

A property of the arithmetic mean is that if every data point in a set is multiplied by a constant factor, the new mean is the original mean multiplied by that same factor. Thus, multiplying by 0.5 results in $(1/2)\bar{x}$.

7. A regular triangular pyramid labeled 1, 2 and 3, is thrown twice and what comes down on a flat surface is observed. What is the probability that the sum of the numbers faced down from this experiment less than 5? (1)

A. $\frac{1}{3}$

B. ✓ $\frac{2}{3}$

C. $\frac{4}{9}$

D. $\frac{5}{9}$

Answer: B

The triangular pyramid has 3 possible outcomes per throw, leading to a sample space of 9. The 6 outcomes that sum to less than 5 are (1,1), (1,2), (1,3), (2,1), (2,2), and (3,1), giving a probability of $6/9 = 2/3$.

8. Which one of the following is the definition of a polynomial function? (1)
- A. A function $f(x) = a_n x^n + a_{n-1} x^{n-1} + \dots + a_1 x + a_0$ where n is a non-negative integer, $a_n \neq 0$ and $\checkmark a_0, a_1, \dots, a_n \in \mathbb{R}$.
- B. A function $f(x) = a_n x^n + a_{n-1} x^{n-1} + \dots + a_1 x^{n+1} + a_0$ where n is a positive integer, $a_n \neq 0$ and $a_0, a_1, \dots, a_n \in \mathbb{R}$.
- C. A function $f(x) = a_n x^n + a_{n-1} x^{n-1} + \dots + a_1 x^{n-1} + a_0$ where n is an integer, $a_n \neq 0$ and $a_0, a_1, \dots, a_n \in \mathbb{R}$.
- D. A function $f(x) = a_n x^n - a_{n-1} x^{n-1} + \dots + a_1 x + a_0$ where n is a rational number, $a_n \neq 0$ and $a_0, a_1, \dots, a_n \in \mathbb{R}$.

Answer: A

A polynomial function is correctly defined as a sum of terms of the form $a_k x^k$ where each exponent k is a non-negative integer and the coefficients are real numbers.

9. When $f(x) = 4x^3 + kx - 1$ is divided by $x - \frac{1}{2}$, the remainder is 3, what is the value of k ? (1)
- A. 14
C. $\frac{7}{2}$
- B. $\checkmark 7$
D. 9

Answer: B

By the Polynomial Remainder Theorem, $f(1/2) = 3$. Substituting $x = 1/2$ gives $4(1/8) + k(1/2) - 1 = 3$, which simplifies to $k/2 - 1/2 = 3$, yielding $k = 7$.

10. What is the solution set of the equation $\log_4(x + 1) - 2\log_4 x = 0.5$? (1)
- A. $\{1, -\frac{1}{2}\}$
C. $\checkmark \{1\}$
- B. $\{\frac{1}{2}, -1\}$
D. $\{\frac{1}{2}\}$

Answer: C

Using logarithm rules, the equation simplifies to $\log_4((x + 1)/x^2) = 1/2$, meaning $(x + 1)/x^2 = 4^{1/2} = 2$. This leads to the quadratic $2x^2 - x - 1 = 0$, which has roots $x = 1$ and $x = -1/2$, but $x = -1/2$ is discarded since $\log_4(x)$ requires $x > 0$.

11. Which of the following is the characteristic of $\log(20 + \frac{1}{5})$? (1)
- A. -1
C. 2.02
- B. $\checkmark 1$
D. 0.2

Answer: B

The value of $20 + 1/5$ is 20.2. Since 20.2 lies between 10^1 and 10^2 , its common logarithm is approximately 1.305, meaning its characteristic (the integer part) is 1.

12. Which of the following is true about a trigonometric value of angles? (1)
- A. $\sin(270^\circ) = 0$
C. $\tan(-90^\circ) = 0$
- B. $\checkmark \cos(-180^\circ) = -1$
D. $\cot(540^\circ) = -1$

Answer: B

The cosine of -180 degrees is the same as the cosine of 180 degrees, which is -1. The other options are incorrect: $\sin(270) = -1$, $\tan(-90)$ is undefined, and $\cot(540)$ is undefined.

13. For $0^\circ \leq \theta \leq 90^\circ$, which of the following relationships describes the co-relationship of angle θ ? (1)

- A. $\cos \theta$ is equal to secant of its complementary angle
- B. $\csc \theta$ is equal to sine of its supplementary angle
- C. ✓ **$\cot \theta$ is equal to tangent of its complementary angle**
- D. $\sec \theta$ is equal to sine of its supplementary angle

Answer: C

Co-functions of complementary angles are equal. Therefore, the cotangent of an angle is equal to the tangent of its complementary angle $(90 - \theta)$.

14. For $0^\circ \leq \theta \leq 90^\circ$, which of the following identity is correct? (1)

- A. ✓ **$\csc^2(90^\circ - \theta) = 1 + \tan^2 \theta$**
- B. $\cot^2(90^\circ - \theta) = 1 + \csc^2 \theta$
- C. $\sec^2 \theta + \tan^2 \theta = 1$
- D. $\cot^2 \theta + \csc^2 \theta = 1$

Answer: A

Using the co-function identity, $\csc(90 - \theta) = \sec \theta$, so $\csc^2(90 - \theta) = \sec^2 \theta$. Applying the Pythagorean identity $\sec^2 \theta = 1 + \tan^2 \theta$ confirms that A is correct.

15. Let ABCD be a Rhombus and E be the mid-point of the shortest diagonal $\overline{AC}$. Then which of the following is NOT true? (1)

- A. $\triangle ABC$ is isosceles
- B. $\overline{AC}$ is perpendicular to BD
- C. $\triangle BEC$ is a right triangle
- D. ✓ **$\triangle DAB$ is an acute angle**

Answer: D

In a rhombus, the diagonals are perpendicular and bisect each other, making options B and C true, and since all sides are equal, triangle ABC is isosceles (option A is true). Since AC is the shortest diagonal, the half-diagonal AE is shorter than BE, making the angle BAE greater than 45 degrees, which means the angle DAB is obtuse (greater than 90 degrees), so option D is NOT true.

16. A person would like to fence all sides of a regular hexagonal polygonal park of radius 12 meter. What is the length of a fencing material needed in meter? (1)

- A. $72\sqrt{3}$
- B. ✓ **72**
- C. $36\sqrt{3}$
- D. 36

Answer: B

For a regular hexagon, the side length is equal to the radius of its circumscribed circle, which is 12 meters. Therefore, the length of the fencing material needed for all 6 sides is $6 \times 12 = 72$ meters.

17. Given a right circular cylinder of base radius 5 cm and lateral surface area 150π sq. cm, which of the following is the volume of the cylinder in cubic centimeters? (1)

- A. ✓ **375π**
- B. 350π
- C. 315.5π
- D. 200π

Answer: A

The lateral surface area is given by $2\pi rh = 150\pi$, which with $r = 5$ cm yields a height of $h = 15$ cm. The volume is then $V = \pi r^2 h = \pi(5)^2(15) = 375\pi$ cubic centimeters.

18. A spherical container of diameter 3 meters is filled with water. What is the amount of the water in the container in cubic meters? (1)

- A. $\frac{27}{4}\pi$ B. $\frac{27}{2}\pi$
C. $\checkmark \frac{9}{2}\pi$ D. $\frac{9}{4}\pi$

Answer: C

The radius of the sphere is half the diameter, $r = 1.5$ meters. The volume of the sphere is $V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(1.5)^3 = 4.5\pi = \frac{9}{2}\pi$ cubic meters.

19. Which of the following is the inverse of $f(x) = \sqrt{x-3}$? (1)

- A. $\checkmark f^{-1}(x) = x^2 + 3, x \geq 0$ B. $f^{-1}(x) = x^2 + 3, x \geq 3$
C. $f^{-1}(x) = \sqrt{x+3}, -\infty < x < \infty$ D. $f^{-1}(x) = \frac{1}{\sqrt{x-3}}, x \geq 3$

Answer: A

Solving $y = \sqrt{x-3}$ for x yields $x = y^2 + 3$, which gives the formula $f^{-1}(x) = x^2 + 3$. Since the range of the original function $f(x) = \sqrt{x-3}$ is $[0, \infty)$, the domain of its inverse $f^{-1}(x)$ must be restricted to $x \geq 0$.

20. Which of the following is the simplified form of (1)

$$\left[x - \frac{x+3}{x-1} \right] \div \frac{x-3}{x^2-2x+1}?$$

- A. $\frac{x^2-2x+3}{x-1}, x \neq 3$ B. $\frac{-1+x}{x-3}, x \neq 1$
C. $\checkmark x^2 - 1, x \neq 1, 3$ D. $x^2 - 2x + 1, x \neq 1, 3$

Answer: C

The expression inside the brackets simplifies to $\frac{x(x-1)-(x+3)}{x-1} = \frac{x^2-2x-3}{x-1} = \frac{(x-3)(x+1)}{x-1}$. Dividing this by $\frac{x-3}{(x-1)^2}$ is equivalent to multiplying by $\frac{(x-1)^2}{x-3}$, which simplifies to $(x+1)(x-1) = x^2 - 1$ for $x \neq 1, 3$.

21. A data on scores of 32 students is listed as follows. 52 48 65 70 50 42 40 61 76 35 55 58 67 60 55 45 60 45 32 66 76 58 75 63 50 75 44 46 78 74 61 52 If the data is to be grouped in 6 classes, what has to be the class interval (w)? (1)

- A. 6 B. 7
C. $\checkmark 8$ D. 9

Answer: C

The range of the data is $\text{Max} - \text{Min} = 78 - 32 = 46$. For 6 classes, the class width w must be at least $\frac{46}{6} \approx 7.67$, which when rounded up to the nearest integer gives a class interval of 8.

22. Five English books, 3 of which identical and 3 different Mathematics books are to be arranged in a row. If one particular Mathematics book is to be placed first, in how many ways can this be done? (1)

- A. 240 B. $\checkmark 840$
C. 5040 D. 6720

Answer: B

With one particular Mathematics book fixed in the first position, we need to arrange the remaining 7 books (2 distinct Mathematics books, 2 distinct English books, and 3 identical English books). The number of distinct ways to arrange them is $\frac{7!}{3!} = \frac{5040}{6} = 840$.

23. Let identical balls labeled 1 to 10 are placed in a box. If a ball is drawn at random, what is the probability that the ball is labeled neither odd nor a multiple of 3? (1)
- A. $\frac{3}{10}$ B. $\frac{1}{2}$
 C. $\frac{3}{5}$ D. $\frac{2}{5}$

Answer: D

In the sample space $S = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$, the numbers that are odd are $\{1, 3, 5, 7, 9\}$ and those that are multiples of 3 are $\{3, 6, 9\}$. The numbers that are neither odd nor a multiple of 3 are $\{2, 4, 8, 10\}$, which gives a probability of $\frac{4}{10} = \frac{2}{5}$.

24. Given the linear system,
$$\begin{cases} a_1x + b_1y + c_1z = 3 \\ a_2x + b_2y + c_2z = -1 \\ a_3x + b_3y + c_3z = 2 \end{cases}$$
, such that the determinant of the coefficient matrix is $\frac{1}{3}$. (1)

Which of the following is the value of y ?

- A. $\frac{1}{3} \begin{vmatrix} a_1 & b_1 & c_1 \\ 3 & -1 & 2 \\ a_3 & b_3 & c_3 \end{vmatrix}$ B. $\frac{1}{3} \begin{vmatrix} a_1 & 3 & c_1 \\ a_2 & -1 & c_2 \\ a_3 & 2 & c_3 \end{vmatrix}$
 C. $-3 \begin{vmatrix} a_1 & b_1 & c_1 \\ -3 & 1 & -2 \\ a_3 & b_3 & c_3 \end{vmatrix}$ D. $\checkmark -3 \begin{vmatrix} a_1 & -3 & c_1 \\ a_2 & 1 & c_2 \\ a_3 & -2 & c_3 \end{vmatrix}$

Answer: D

By Cramer's Rule, $y = \frac{\det(D_y)}{\det(D)} = 3 \det(D_y)$ since $\det(D) = 1/3$. Since multiplying a column of a matrix by -1 multiplies its determinant by -1 , the expression in D simplifies to $-3 \cdot (-1) \det(D_y) = 3 \det(D_y)$, which is the correct value of y .

25. If $w = i - \frac{3+i}{5}$, then which of the following is equal to the modulus of w ? (1)
- A. $\frac{3}{5}\sqrt{5}$ B. $\checkmark 1$
 C. $1 - \frac{1}{5}\sqrt{10}$ D. $1 + \frac{1}{5}\sqrt{10}$

Answer: B

Simplifying w gives $w = i - \frac{3}{5} - \frac{i}{5} = -\frac{3}{5} + \frac{4}{5}i$. Its modulus is $|w| = \sqrt{\left(-\frac{3}{5}\right)^2 + \left(\frac{4}{5}\right)^2} = \sqrt{\frac{9}{25} + \frac{16}{25}} = 1$.

26. Few terms of a sequence are given as follows: -2, 0, 4, 10, ... Which of the following can be a fifth term? (1)
- A. 14 B. 16
 C. $\checkmark 18$ D. 20

Answer: C

The differences between consecutive terms of the sequence -2, 0, 4, 10 are 2, 4, 6, which increase by 2 each time. Continuing this pattern, the next difference is 8, making the fifth term $10 + 8 = 18$ (which fits the quadratic sequence formula $a_n = n^2 - n - 2$).

27. For the arithmetic sequence with $A_3 = 5$ and $A_5 = 10$, which of the following is the sum of the first 20 terms? (1)
- A. $\checkmark 475$ B. 495
 C. 570 D. 950

Answer: A

For the arithmetic sequence, the difference is $2d = A_5 - A_3 = 5$, so $d = 2.5$. The first term is $A_1 = A_3 - 2d = 5 - 5 = 0$. The sum of the first 20 terms is $S_{20} = \frac{20}{2}[2A_1 + 19d] = 10[0 + 47.5] = 475$.

The class midpoints are 10, 15, 20, 25, and 30. The mean is $(30 + 60 + 100 + 150 + 60) / 20 = 20$. The population variance is the average of the squared deviations weighted by frequency: $(3(100) + 4(25) + 5(0) + 6(25) + 2(100)) / 20 = 750 / 20 = 37.5$, so the standard deviation is $\sqrt{37.5}$.

33. Given two sets of data A and B with ranges 15 and 15 respectively, coefficient of range (CR) of A is 0.2 and CR of B is 0.21. Then which of the following is true? (1)
- A. The dispersion of A is slightly greater than that of B.
- B. ✓ **The dispersion of B is slightly greater than that of A.**
- C. Data A has the same dispersion as B even if CR varies.
- D. No enough information to compare dispersion roughly.

Answer: B

The coefficient of range is a relative measure of dispersion. Because the coefficient of range for B (0.21) is greater than that of A (0.20), data set B has a slightly greater relative dispersion than data set A.

34. In a homogeneous population where there is a categorical difference, items are selected randomly in each category. Which of the following describes the sampling method stated above? (1)
- A. Simple random sampling
- B. Systematic sampling
- C. ✓ **Stratified sampling**
- D. Cluster sampling

Answer: C

Stratified sampling involves dividing a population into non-overlapping subgroups (categories or strata) and then taking a simple random sample from each subgroup.

35. Which one of the following is the minimum value of the following linear programming problem? Minimize: $Z = 3x + y$ Subject to: $y \geq -x + 4$, $y \geq 5x - 20$, $x \geq 1$, $y \leq 5$ (1)
- A. 12
- B. 8
- C. 4
- D. ✓ **6**

Answer: D

The corner points of the feasible region formed by the constraints are (4, 0), (1, 3), (1, 5), and (5, 5). Evaluating the objective function $Z = 3x + y$ at these points gives 12, 6, 8, and 20 respectively, making the minimum value 6.

36. An agent planned to transport fertilizers in barrels and sacks from a port. The agent can transport 30 barrels and 50 sacks charging Birr 8,000 for a trip, and each car B can transport 45 barrels and 80 sacks charging Birr 12,000. If there are at least 400 barrels and at most 1,500 sacks to be transported from the port, which of the following is a constraint of the linear programming problem to minimize the cost of transportation given by $z = 8,000x + 12,000y$? (1)
- A. ✓ $\begin{cases} 6x + 9y \geq 80 \\ 5x + 8y \leq 150 \\ x \geq 0, y \geq 0 \end{cases}$
- B. $\begin{cases} 6x + 9y \leq 80 \\ 5x + 8y \geq 150 \\ x \geq 0, y \geq 0 \end{cases}$
- C. $\begin{cases} 3x + 5y \geq 40 \\ 9x + 16y \leq 30 \\ x \geq 0, y \geq 0 \end{cases}$
- D. $\begin{cases} 3x + 5y \leq 40 \\ 9x + 16y \geq 30 \\ x \geq 0, y \geq 0 \end{cases}$

Answer: A

Let x be the number of trips of car A (the agent) and y be the number of trips of car B. Since car A carries 30 barrels and car B carries 45 barrels, to transport at least 400 barrels we need $30x + 45y \geq 400$, which simplifies to $6x + 9y \geq 80$. Similarly, for at most 1,500 sacks, we have $50x + 80y \leq 1500$, which simplifies to $5x + 8y \leq 150$.

- 37.** A college graduate plans to deposit Birr 2000 each year starting from the first day of the year into a saving account that pays 8% interest compounded annually. How much will he/she have just after the first day of the third year?
- A. *Birr*4492.2
B. *Birr*6332.8
C. ✓ *Birr*6492.8
D. *Birr*7012.2

Answer: C

On the first day of Year 1, a deposit of Birr 2000 is made. By the end of Year 1 (which is the beginning of Year 2), it grows to $2000 \times 1.08 = 2160$ Birr. After adding the second deposit of 2000 Birr, the balance is 4160 Birr. By the end of Year 2 (beginning of Year 3), this grows to $4160 \times 1.08 = 4492.8$ Birr. Just after the third deposit on the first day of Year 3, the total amount is $4492.8 + 2000 = 6492.8$ Birr.

- 38.** In order to safeguard the property of a lessor, rent tax on income per year is set as per the following rate. (1)
- | | |
|------------------------|------------------------|
| Taxable income in Birr | Tax Rate in percentage |
| 0 to 7200 | 0 |
| Exempted 7201 to 19800 | 10 |
| 19801 to 38400 | 15 |
| 38401 to 63,000 | 20 |
- In 2015 E.C, if a building was rented for 8 months at Birr 4,500 per month, what was the amount of rental tax paid at the end of the year?
- A. *Birr*3390
- B. ✓ *Birr*3690
- C. *Birr*3960
- D. *Birr*4390

Answer: B

The annual rental income is $8 \times 4500 = 36000$ Birr. Using the progressive rental tax brackets: the first 7,200 Birr is exempt (0% tax); the next interval $(19800 - 7200) = 12600$ Birr is taxed at 10% (1260 Birr); and the remaining income $(36000 - 19800) = 16200$ Birr is taxed at 15% (2430 Birr). The total tax paid is $1260 + 2430 = 3690$ Birr.

END OF THE MARKING KEY

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