

Mathematics, 2018 EC, entrance exam, version 2

Grade 12 · Mathematics · 2018 E.C.

MARKING KEY: CONFIDENTIAL

Time allowed: 120 minutes

Questions: 56

Total marks: 56

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1. What is the 10th term of Prof. Mulatu's sequence ? (1)

- A. 309 B. ✓ 118
C. 191 D. 89

Answer: B

The Mulatu sequence starts with $M_1 = 4$ and $M_2 = 1$, with subsequent terms defined by $M_n = M_{n-1} + M_{n-2}$.
Generating the terms gives: 4, 1, 5, 6, 11, 17, 28, 45, 73, 118, so the 10th term is 118.

2. What is the area (in square unit) of the region bounded by $y=0$ and the graph of $f(x)=4-x^2$ on the interval $[-2,2]$? (1)

- A. $2/3$ B. $22/3$
C. 8 D. ✓ $32/3$

Answer: D

The area is given by the definite integral $\int_{-2}^2 (4 - x^2) dx = [4x - \frac{x^3}{3}]_{-2}^2 = (8 - \frac{8}{3}) - (-8 + \frac{8}{3}) = \frac{16}{3} + \frac{16}{3} = \frac{32}{3}$ square units.

3. Let f be defined on $[a, b]$. Then which of the following is NOT true? (1)

- A. ✓ $\int_a^b f(x) dx = \int_a^c f(x) dx - \int^c_b f(x) dx$ for any c in (a, b)
B. $\int^c_c f(x) dx = 0$ for any c in (a, b)
C. $\int_a^b f(x) dx = -\int_b^a f(x) dx$
D. $\int_a^b k f(x) dx = k \int_a^b f(x) dx$ for any constant k

Answer: A

By the interval union property of definite integrals, $\int_a^b f(x) dx = \int_a^c f(x) dx + \int_c^b f(x) dx$ for any $c \in (a, b)$, which makes the minus sign in option A incorrect.

4. The sides of an equilateral triangle are increasing at the rate of 2 cm/sec. The rate at which the area increases when side is 10 cm is: (1)

- A. $10 \text{ cm}^2/\text{sec}$ B. $\sqrt{3} \text{ cm}^2/\text{sec}$
C. ✓ $10\sqrt{3} \text{ cm}^2/\text{sec}$ D. $10/3 \text{ cm}^2/\text{sec}$

Answer: C

The area of an equilateral triangle is $A = \frac{\sqrt{3}}{4} s^2$. Differentiating with respect to time t gives $\frac{dA}{dt} = \frac{\sqrt{3}}{2} s \frac{ds}{dt} = \frac{\sqrt{3}}{2} (10)(2) = 10\sqrt{3} \text{ cm}^2/\text{sec}$.

5. A balloon which always remains spherical is being inflated by pumping in 10 cm^3 of gas per second. What is the rate at which the radius is increasing when the radius is 15 cm ? (1)
- A. $\frac{1}{(30\pi)} \text{ cm/sec}$
- B. ✓ $\frac{1}{(90\pi)} \text{ cm/sec}$
- C. $\frac{1}{\pi} \text{ cm/sec}$
- D. $\frac{1}{(9\pi)} \text{ cm/sec}$

Answer: B

The volume of a sphere is $V = \frac{4}{3}\pi r^3$, so $\frac{dV}{dt} = 4\pi r^2 \frac{dr}{dt}$. Given $\frac{dV}{dt} = 10$ and $r = 15$, we get $10 = 4\pi(15)^2 \frac{dr}{dt}$, which simplifies to $\frac{dr}{dt} = \frac{10}{900\pi} = \frac{1}{90\pi}$ cm/sec.

- 6.** Suppose Target Population N = 54000 vouchers and sample size n = 6000; following the systematic sampling approach if 4th unit is selected as the first unit in the sample then the next unit selected in the sample would be:
- A. 8th B. 10th
C. 12th D. ✓ 13th

Answer: D

The sampling interval is $k = N/n = 54000/6000 = 9$. If the first selected unit is the 4th, the next systematic unit is $4 + 9 = 13$ th.

7. The standard deviation and arithmetic mean of aggregate marks obtained by three groups of students X, Y, Z are as follows: X: mean=53, sd=21; Y: mean=83, sd=19; Z: mean=50, sd=10. The more variable group is:
- A. ✓ X B. Y
C. Z D. X&Z

Answer: A

The relative variability is measured by the coefficient of variation ($CV = sd/mean$). For group X, $CV = 211/53 \approx 3.98$ (or $21/53 \approx 0.40$ if it is a typo for 21), which is greater than Y ($19/83 \approx 0.23$) and Z ($10/50 = 0.20$), making group X the most variable.

- 8.** When the variability of two series is to be compared, which of the following should be used? (1)
- A. Absolute measure of average B. Absolute measure of dispersion
- C. ✓ **Relative measure of dispersion** D. Relative measure of average

Answer: C

A relative measure of dispersion (such as the coefficient of variation) is unit-free and is used to compare the variability of two or more distributions with different units or averages.

9. A rectangular page contains 24 square inches of print. The margins: top and bottom 1.5 inch, left and right 1 inch. What dimensions of the page produce the smallest area?
- A. 6 by 4 B. 8 by 6
- C. ✓ 6 by 9 D. 10 by 8

Answer: C

Let x and y be the dimensions of the print area, so $xy = 24$. The page area is $A = (x + 2)(y + 3) = (x + 2)(\frac{24}{x} + 3) = 30 + 3x + \frac{48}{x}$. Differentiating gives $3 - \frac{48}{x^2} = 0 \implies x = 4$, which yields page dimensions of $x + 2 = 6$ by $y + 3 = 9$ inches.

- 10.** If there are many extreme scores in all examinations, the dispersion is _____ (1)
- A. ✓ Large B. Small
- C. Normal D. Symmetric

Answer: A

Extreme scores (outliers) lie far away from the center of the data set. Having many such extreme values increases the spread, and thus the dispersion of the data becomes large.

- 11.** If the values of variable x are -4, -20, -30, -44 and -36, then the value of range will be
- A. -48 B. ✓ **40**
- C. -40 D. 48

Answer: B

The range is the difference between the maximum and minimum values in the dataset. Here, $\text{Range} = \text{Max} - \text{Min} = -4 - (-44) = 40$.

12. A particle moves along the x-axis with acceleration $a(t)=12t^2+6t$ for $t \geq 0$. If $v(1)=5$ and $s(0)=2$, then what is position at $t=2$ sec? (1)
- A. 26 m
B. 12 m
C. 24 m
D. ✓ 22 m

Answer: D

Integrating acceleration $a(t) = 12t^2 + 6t$ gives $v(t) = 4t^3 + 3t^2 + C_1$. Since $v(1) = 5$, $C_1 = -2$. Integrating $v(t)$ gives $s(t) = t^4 + t^3 - 2t + C_2$, and since $s(0) = 2$, $C_2 = 2$. Thus, $s(2) = 16 + 8 - 4 + 2 = 22$ m.

- 13.** If pth term of an arithmetic progression is q and its (p+q)th term is 0, then qth term is equal to:
- A. -p B. p+q
C. ✓ p D. p-q

Answer: C

In an AP, let $a_n = a_1 + (n - 1)d$. We have $a_p = a_1 + (p - 1)d = q$ and $a_{p+q} = a_1 + (p + q - 1)d = 0$. Subtracting these equations gives $qd = -q \implies d = -1$. Substituting d gives $a_1 = p + q - 1$, so $a_q = a_1 + (q - 1)d = (p + q - 1) - (q - 1) = p$.

14. Which one of the following sequence is both arithmetic and geometric? (1)
- A. $-1, 1, -1, 1, \dots$ B. $\checkmark \ 1/3, 1/3, 1/3, 1/3, \dots$
- C. $0, 2, 2, 2, \dots$ D. $25, 5, 1/5, 1/25, \dots$

Answer: B

A constant sequence is both arithmetic (with common difference $d = 0$) and geometric (with common ratio $r = 1$, provided the constant is non-zero).

15. A ball is dropped from a height of 64 meters. Each time it bounces, it reaches half the previous height. Total distance traveled before coming to rest?
- A. 128 m
B. ✓ 192 m
C. 256 m
D. 320 m

Answer: B

The ball travels 64 meters on the first drop, then bounces up and down heights of 32, 16, 8, ... meters. The total distance is $64 + 2(32 + 16 + 8 + \dots) = 64 + 2(\frac{32}{1-0.5}) = 64 + 128 = 192$ meters.

16. If 7th and 21st terms of arithmetic sequence are 24 and 52 respectively, then sum of first 5 terms is: (1)
- A. 65
B. ✓ 80
C. 82
D. 90

Answer: B

For an AP, $a_7 = a_1 + 6d = 24$ and $a_{21} = a_1 + 20d = 52$. Subtracting gives $14d = 28 \implies d = 2$, which means $a_1 = 12$. The sum of the first 5 terms is $S_5 = \frac{5}{2}[2(12) + 4(2)] = 80$.

17. If the sequence defined recursively by $a_1=1$, $a_2=-1$ and $a_n = a_{n-1} + 2a_{n-2} + n$ for $n \geq 3$, then seventh term is: (1)
- A. ✓ 82
B. 75
C. 120
D. 37

Answer: A

Using the recurrence relation $a_n = a_{n-1} + 2a_{n-2} + n$, we compute: $a_1 = 1$, $a_2 = -1$, $a_3 = 4$, $a_4 = 6$, $a_5 = 19$, $a_6 = 37$, and $a_7 = 37 + 2(19) + 7 = 82$.

18. If the sum of first n terms of arithmetic progression is $2n+3n^2$, then a_n is equal to (1)
- A. $4n+3$
B. $6n+5$
C. ✓ $6n-1$
D. $4n-1$

Answer: C

The n -th term is $a_n = S_n - S_{n-1} = (2n + 3n^2) - (2(n-1) + 3(n-1)^2) = (3n^2 + 2n) - (3n^2 - 4n + 1) = 6n - 1$.

19. What is equation of normal line to the graph of $f(x)=(1-x^3)\sqrt{x+5}$ at $(-1,4)$? (1)
- A. $2y+11x=-3$
B. $2y-11x=19$
C. ✓ $11y-2x=46$
D. $11y+2x=42$

Answer: C

The derivative of $f(x) = (1 - x^3)\sqrt{x+5}$ at $x = -1$ is $f'(-1) = -3(-1)^2\sqrt{4} + (2)\frac{1}{2\sqrt{4}} = -6 + \frac{1}{2} = -\frac{11}{2}$. The slope of the normal is $m_n = \frac{2}{11}$. The equation is $y - 4 = \frac{2}{11}(x + 1) \implies 11y - 2x = 46$.

20. If $f(x)=x^3+ax^2+bx-2$ has relative minimum value of 6 at $x=1$, then equation of tangent line at $x=-1$ is: (1)
- A. ✓ $y-40x=10$
B. $y=40x-10$
C. $y-40x=70$
D. $y=40x-70$

Answer: A

Using $f(1) = 6$ and $f'(1) = 0$ for $f(x) = x^3 + ax^2 + bx - 2$, we get $a + b = 7$ and $2a + b = -3$, which solve to $a = -10$ and $b = 17$. At $x = -1$, $f(-1) = -30$ and $f'(-1) = 40$, giving the tangent line equation $y - (-30) = 40(x - (-1)) \implies y - 40x = 10$.

21. In which case is the interquartile range preferred over the range? (1)
- A. When data is binary
B. When focusing on extreme values
C. ✓ When analyzing the middle 50% of the data
D. For data set with identical values

Answer: C

The interquartile range (IQR) measures the spread of the middle 50% of the data and is preferred over the range when the dataset contains outliers, as the range is highly sensitive to extreme values.

22. In case of positively skewed distribution, the extreme values lie in the: (1)
- A. Middle
B. Left tail
C. ✓ **Right tail**
D. Anywhere

Answer: C

A positively skewed distribution has a long tail extending to the right, which means that the extreme, unusually large values lie in the right tail of the distribution.

23. The output of 20 workers: 55,65,62,60,74,75,70,70,72,67,78,79,80,68,54,56,63,69,63,71. Then coefficient of range is: (1)
- A. 0.29
B. ✓ **0.19**
C. 0.49
D. 0.39

Answer: B

The maximum value is $H = 80$ and the minimum value is $L = 54$. The coefficient of range is $\frac{H-L}{H+L} = \frac{80-54}{80+54} = \frac{26}{134} \approx 0.19$.

24. The following data: 50,69,20,33,53,39,40,65,59. The mean deviation about the median is: (1)
- A. 9
B. 10.5
C. ✓ **12.67**
D. 14.76

Answer: C

The median of the sorted data is 50. The sum of the absolute deviations of the data points from 50 is $30 + 17 + 11 + 10 + 0 + 3 + 9 + 15 + 19 = 114$, giving a mean deviation of $114 / 9 \approx 12.67$.

25. A smaller value of coefficient of variation indicates: (1)
- A. Higher variability
B. More skewness
C. ✓ **Higher consistency**
D. More central tendency

Answer: C

The coefficient of variation measures relative variability; therefore, a smaller value indicates that the data points are less dispersed around the mean, representing higher consistency.

26. Bowley's coefficient of skewness lies between: (1)
- A. 0 and 1
B. ✓ **-1 and 1**
C. -1 and 0
D. -2 and 2

Answer: B

Bowley's coefficient of skewness is defined as $(Q_3 + Q_1 - 2*Q_2) / (Q_3 - Q_1)$. Since $Q_1 \leq Q_2 \leq Q_3$, this value is mathematically bounded between -1 and 1.

27. The lower and upper quartiles are 80 and 120, median 100. The shape of distribution is: (1)
- A. Positively skewed
B. Negatively skewed
C. ✓ **Symmetrical**
D. Elongated to the right

Answer: C

Bowley's coefficient of skewness is $(120 + 80 - 2*100) / (120 - 80) = 0$. A skewness coefficient of zero indicates that the distribution is symmetrical.

28. The sum of the deviations of all data points from the mean is always: (1)

- A. Positive
B. ✓ Zero
C. Negative
D. Equal to range

Answer: B

The sum of the deviations of all data points from their mean is always zero, as $\sum(x_i - \bar{x}) = \sum x_i - n\bar{x} = n\bar{x} - n\bar{x} = 0$.

29. What is the sum of all integers between 20 and 201 that are divisible by 2 or 5? (1)

- A. 16,110
B. 12,970
C. 16,150
D. ✓ 11,970

Answer: D

For integers strictly between 20 and 201, the sum of those divisible by 2 or 5 is calculated using inclusion-exclusion: $S_2 + S_5 - S_{10} = 9990 + 4050 - 2070 = 11,970$.

30. Which one of the following is true about $f(x) = x^4 - (4/3)x^3$? (1)

- A. f is decreasing on $[1, \infty)$
B. ✓ The function has no relative extreme at $x=0$
C. f is increasing on $(-\infty, 1]$
D. $f(1)$ is local maximum

Answer: B

The derivative is $f'(x) = 4x^2(x - 1)$, which has critical points at $x = 0$ and $x = 1$. Since $f'(x)$ does not change sign at $x = 0$, the function has no relative extremum there.

31. A particle position $s(t) = t^4 - 3t + 5$. Which one is true? (1)

- A. $v(t) = t^5/5 - 3t^2/2 + 5t$
B. $v(2) = 4.4$ m/s
C. Particle at rest at $t = 3/4$ sec
D. ✓ $a(1) = 12$ m/s²

Answer: D

The velocity is $v(t) = s'(t) = 4t^3 - 3$ and the acceleration is $a(t) = v'(t) = 12t^2$. Thus, at $t = 1$, the acceleration is $a(1) = 12$ m/s².

32. If $f(2) = -3$, $f'(2) = 4$, $g(1) = -5$, $g'(1) = 1$, and $F(x) = f(2x+2) \cdot g(1-x^2)$, then $F'(0)$ is: (1)

- A. ✓ -40
B. 0
C. -20
D. 19

Answer: A

By the product and chain rules, $F'(x) = 2f'(2x+2)g(1-x^2) - 2xf(2x+2)g'(1-x^2)$. Substituting $x = 0$ yields $F'(0) = 2f'(2)g(1) = 2(4)(-5) = -40$.

33. If $f(x) = 2x^2 + 5x + 8$, then $[f(2+h) - f(2)]/h$ as $h \rightarrow 0$ is equal to (1)

- A. 9
B. 15
C. ✓ 13
D. 26

Answer: C

The limit represents the definition of the derivative $f'(2)$. Since $f'(x) = 4x + 5$, substituting $x = 2$ gives $f'(2) = 13$.

40. Average rate of change of $f(x)=x\sqrt{x} - x^2 + 4x - 2$ between $x=1$ and $x=4$ is: (1)
- A. $-10/6$ B. ✓ $4/3$
C. 3 D. B?

Answer: B

The average rate of change is $(f(4) - f(1)) / (4 - 1)$. Evaluating the function gives $f(4) = 6$ and $f(1) = 2$, so the average rate is $(6 - 2) / 3 = 4/3$.

41. Which best describes instantaneous rate of change? (1)
- A. Slope of secant line B. ✓ **Slope of tangent line at a point**
C. Rate over entire period D. Same as derivative over interval

Answer: B

The instantaneous rate of change of a function at a specific point is geometrically represented by the slope of the tangent line to the function's curve at that point.

42. For a survey, a village is divided into 5 lanes then each lane is sampled randomly. This is an example of: (1)
- A. Simple Random Sampling B. ✓ **Stratified Random Sampling**
C. Systematic Random Sampling D. Multi stage Sampling

Answer: B

Dividing the population into distinct subgroups (lanes) and then selecting random samples from each subgroup is the definition of Stratified Random Sampling.

43. Which is true about Simple Random Sampling? (1)
- A. Provides least number of possible samples
B. Every fixed unit is taken
C. ✓ **All units have equal chance to be selected**
D. Only selected units have right

Answer: C

By definition, Simple Random Sampling is a sampling method where every individual unit in the population has an equal probability of being selected.

44. The third term of geometric progression is 3. What is the product of the first five terms? (1)
- A. 216 B. 226
C. ✓ **243** D. 729

Answer: C

The third term of a GP is $a_3 = ar^2 = 3$. The product of the first five terms is $a * (ar) * (ar^2) * (ar^3) * (ar^4) = (ar^2)^5 = 3^5 = 243$.

45. The sum of first n terms of the sequence $1/(2 \cdot 5), 1/(5 \cdot 8), 1/(8 \cdot 11), \dots$ is: (1)
- A. ✓ **$n/(6n+4)$** B. $3n/(6n+4)$
C. $(3n+1)/(18n+12)$ D. $n/(4n+6)$

Answer: A

The general term is $T_k = 1/((3k-1)(3k+2)) = (1/3) * (1/(3k-1) - 1/(3k+2))$. The telescoping sum of the first n terms simplifies to $(1/3) * (1/2 - 1/(3n+2)) = n / (6n + 4)$.

46. Which is true about cluster sampling? (1)
- A. Every nth case is chosen
 - B. ✓ **A natural group is taken as sampling unit**
 - C. Involves random numbers
 - D. Stratification of population

Answer: B

In cluster sampling, the population is partitioned into naturally occurring groups called clusters, which are then selected at random as the primary sampling units.

47. A business gets net profit of Birr 3000 at the end of each month. Just after the 5th year, its amount was Birr 230,000. What was the starting amount? (1)
- A. Birr 47,000
 - B. Birr 53,000
 - C. ✓ **Birr 50,000**
 - D. Birr 56,000

Answer: C

The total profit accumulated over 5 years (60 months) is $60 \times \text{Birr } 3000 = \text{Birr } 180,000$. Subtracting this from the final amount of Birr 230,000 gives a starting amount of Birr 50,000.

48. The sequence $\{a_n\}$ with $a_1=2$ and $a_{n+1}=a_n+4$, then $\sum_{n=3}^{35} a_n$ equals: (1)
- A. 2460
 - B. 2458
 - C. 2450
 - D. ✓ **2442**

Answer: D

The sequence is an arithmetic progression with first term $a_1 = 2$ and common difference $d = 4$, so $a_n = 4n - 2$. The sum from $n=3$ to $n=35$ has 33 terms, with $a_3 = 10$ and $a_{35} = 138$, giving a sum of $33 \times (10 + 138) / 2 = 2442$.

49. Find natural number a such that $\sum_{k=1}^n f(a+k) = 16(2^n - 1)$ where f satisfies $f(x+y)=f(x)f(y)$ and $f(1)=2$. (1)
- A. ✓ **3**
 - B. 4
 - C. 6
 - D. 5

Answer: A

The functional equation $f(x+y)=f(x)f(y)$ with $f(1)=2$ yields $f(x)=2^x$. Thus, the sum is $2^a \times \sum_{k=1}^n 2^k = 2^a \times 2(2^n - 1) = 2^{a+1} \times (2^n - 1)$, which equals $16(2^n - 1)$ when $a+1 = 4$, so $a = 3$.

50. The sum of absolute deviations is minimum if these deviations are taken from (1)
- A. Mean
 - B. Mode
 - C. ✓ **Median**
 - D. Q_3

Answer: C

A fundamental property of the median is that it minimizes the sum of absolute deviations of a set of data points.

51. Which of the following is unit free quantity? (1)
- A. Range
 - B. ✓ **Coefficient of variation**
 - C. Standard Deviation
 - D. Arithmetic mean

Answer: B

The coefficient of variation is calculated as the ratio of the standard deviation to the mean, which cancels out the units, making it a dimensionless (unit-free) measure of relative dispersion.

52. The sum of $\sum_{n=1}^{\infty} 5(2/3)^n$ is: (1)
- A. $10/3$ B. 15
C. 5 D. ✓ 10

Answer: D

This is an infinite geometric series with first term $a = 5(2/3) = 10/3$ and common ratio $r = 2/3$. Its sum is $a / (1 - r) = (10/3) / (1 - 2/3) = 10$.

53. Which one is anti-derivative of $f(x)=3/(x\sqrt{x})$? (1)
- A. ✓ $-6/\sqrt{x} + c$ B. $-6\sqrt{x} + c$
C. $6/\sqrt{x} + c$ D. $-3/(2\sqrt{x}) + c$

Answer: A

Rewriting $f(x)$ as $3 * x^{(-3/2)}$, its antiderivative is obtained using the power rule: integral of $3 * x^{(-3/2)} dx = 3 * (x^{(-1/2)} / (-1/2)) + c = -6/\sqrt{x} + c$.

54. Suppose $\int_8^6 f(x)dx = 21$ and $\int_1^6 f(x)dx = -12$, then $\int_1^8 f(x)dx$ is: (1)
- A. 9 B. -9
C. 33 D. ✓ -33

Answer: D

Using the properties of definite integrals, $\int_1^8 f(x)dx = \int_1^6 f(x)dx + \int_6^8 f(x)dx = -12 - \int_8^6 f(x)dx = -12 - 21 = -33$.

55. If f and g are defined on $\mathbb{R}$ and $a, b \in \mathbb{R}$, which is necessary true? (1)
- A. If $\int f = \int g$, then $f=g$ B. If $f'=g'$, then $\int f = \int g$
C. ✓ If $f(x) \geq 3$ on $[-2, 2]$, then $\int_{-2}^2 f \geq 12$ D. $\int f = \int f$

Answer: C

By the comparison property of integrals, if $f(x) \geq m$ on $[a, b]$, then the integral of f from a to b is $\geq m(b - a)$. Here, $m = 3$ and $b - a = 2 - (-2) = 4$, so the integral is ≥ 12 .

56. Mean deviation computed from a set of data is always: (1)
- A. Negative B. Equal to standard deviation
C. More than standard deviation D. ✓ Less than standard deviation

Answer: D

By the Cauchy-Schwarz inequality, the mean absolute deviation of a dataset is always less than or equal to its standard deviation, and is strictly less for most non-trivial datasets.

END OF THE MARKING KEY

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