

10. Which one of the following is always true about a polynomial function of degree 3? (1)
- A. It has three zeros
B. ✓ Its range is $\mathbb{R}$
C. It may not cross the x -axis
D. It crosses the x -axis three times

Answer: B

A polynomial of degree 3 has an odd leading power, so for large x the graph runs to $+\infty$ at one end and $-\infty$ at the other. A polynomial is continuous, so it takes every value in between, and the range is all of $\mathbb{R}$. Option A sounds safe because a cubic has three roots when complex roots are counted, but the real graph need not cross the x -axis three times. The curve $f(x) = x^3 + x$ crosses it once.

11. The simplified form of $\log_{4x}(4x^{-1}) + 4 \log_{4x}(2x^2) - 4 \log_{4x} x$ is: (1)
- A. ✓ 3
B. 4
C. $1/4$
D. $\sqrt{4}$

Answer: A

Gather the three terms into one logarithm with base $4x$, using $4 \log_{4x}(2x^2) = \log_{4x}(2x^2)^4$ and the same for the last term. The inside becomes $\frac{(\frac{4}{x})(2x^2)^4}{x^4}$. Now $(2x^2)^4 = 16x^8$, so $\frac{4}{x} \times 16x^8 = 64x^7$, and dividing by x^4 leaves $64x^3$. Since $64x^3 = (4x)^3$, the expression is $\log_{4x}(4x)^3 = 3$. Option B is the coefficient 4 that sits in front of the middle term, which is not the value of the whole expression.

12. What is the simplified form of $(2^{\sqrt{5}} \times 2^{\sqrt{20}}) / 8^{\sqrt{5}}$? (1)
- A. ✓ 1
B. 2
C. $2^{\sqrt{5}}$
D. $\sqrt{2}$

Answer: A

Put everything over base 2. Since $\sqrt{20} = \sqrt{4 \times 5} = 2\sqrt{5}$, the numerator is $2^{\sqrt{5}} \times 2^{2\sqrt{5}} = 2^{3\sqrt{5}}$. The denominator is $8^{\sqrt{5}} = (2^3)^{\sqrt{5}} = 2^{3\sqrt{5}}$. Top and bottom are the same number, so the value is 1. Option C is what is left if you cancel $2^{\sqrt{20}}$ against part of the denominator and stop there, forgetting that $8^{\sqrt{5}} = 2^{3\sqrt{5}}$ still has one more $2^{\sqrt{5}}$ waiting to cancel.

13. Which one of the following is true about the graph of $f(x) = 1 + (1/2)^x$? (1)
- A. It is increasing on $[0, \infty)$
B. The x -axis is its asymptote
C. It intersects the y -axis at $(0, 1)$
D. ✓ for $x > 0$, it lies between the lines $y = 1$ and $y = 2$

Answer: D

The base $\frac{1}{2}$ is less than 1, so $(1/2)^x$ shrinks as x grows. For every $x > 0$ it sits strictly between 0 and 1. Adding 1 lifts the whole graph, so $f(x)$ sits strictly between 1 and 2 for those x . Option B is close but wrong: the graph flattens towards the line $y = 1$, not towards the x -axis, because of that $+1$.

14. Let $f(x) = \log_{1/9} x$, then which one is true about $f(x)$? (1)
- A. f is an increasing function
B. $y = 0$ is asymptote of f
C. ✓ for each $x \in (0, 1)$, $f(x) > 0$
D. it has y -intercept

Answer: C

The base is $\frac{1}{9}$, which is less than 1, so this logarithm decreases as x grows. Write it as $f(x) = \frac{\ln x}{\ln(1/9)}$. For x between 0 and 1 the top $\ln x$ is negative, and the bottom $\ln(1/9)$ is negative too, so the quotient comes out positive. Option A would be right for a base bigger than 1, for example $\log_9 x$, but a base under 1 turns the graph the other way.

15. If $\log_x 64 + \log_x (1/8) = 3/5$, then x is equal to: (1)

- A. ✓ 32
B. 16
C. 8
D. 4

Answer: A

Combine the two logarithms first: $\log_x 64 + \log_x \frac{1}{8} = \log_x \left(64 \times \frac{1}{8}\right) = \log_x 8$. So $\log_x 8 = \frac{3}{5}$, which in exponent form is $x^{3/5} = 8$. Raise both sides to the power $\frac{5}{3}$: $x = 8^{5/3} = (2^3)^{5/3} = 2^5 = 32$. Option C is the number 8 from inside the logarithm, but the question asks for the base.

16. Which one of the following is a power function? (1)

- A. ✓ $f(x) = (2/3)\sqrt{x}$
B. $f(x) = (2/3)^x$
C. $f(x) = 2x^4 - 1$
D. $f(x) =$

Answer: A

A power function has the shape $f(x) = kx^p$: one fixed number multiplied by x raised to a fixed power. Here $\frac{2}{3}\sqrt{x} = \frac{2}{3}x^{1/2}$, which fits with $k = \frac{2}{3}$ and $p = \frac{1}{2}$. Option B, $(2/3)^x$, is an exponential function, because there the variable sits up in the exponent and the base is the fixed number. Option C is a polynomial with an extra constant term, so it is not a single power of x either.

17. Which one of the following statement define the greatest integer function given by $f(x)=|x|$? Wait, the text says 'f(x)=|x|' but that's absolute value, not greatest integer. Probably a misprint. The options describe floor function. It says: 'Which one of the following statement define the greatest integer function given by $f(x)=|x|$?' Actually greatest integer is floor. Options: A. It is the least integer greater than or equal to x . B. It is an integer greater than or equal to x . C. It is an integer less than or equal to x . D. It is the greatest integer less than or equal to x . So D is definition of floor function. Answer D. (1)

- A. least integer $\geq x$
B. integer $\geq x$
C. integer $\leq x$
D. ✓ greatest integer $\leq x$

Answer: D

The greatest integer function, written $\lfloor x \rfloor$, sends x to the largest whole number that is not above x . At $x = 3.7$ it gives 3, and at $x = -1.2$ it gives -2 . Option C says only that the value is an integer less than or equal to x , and many integers fit that at once: 1, 2 and 3 are all under 3.7. A function must return one value for each input, so the word "greatest" is what completes the definition.

18. The inverse of the function defined by $f(x) = 3x/(x+2)$ is (1)

- A. ✓ $f^{-1}(x) = -2x/(x-3)$
B. $f^{-1}(x) = 2x/(x-3)$
C. $f^{-1}(x) = -2x/(x+3)$
D. $f^{-1}(x) = 2x/(x+3)$

Answer: A

Set $y = \frac{3x}{x+2}$ and make x the subject. Multiply out: $y(x+2) = 3x$, so $xy + 2y = 3x$. Collect the x terms on one side: $xy - 3x = -2y$, so $x(y-3) = -2y$ and $x = \frac{-2y}{y-3}$. Renaming the input gives $f^{-1}(x) = \frac{-2x}{x-3}$. Option B is the same shape with a lost minus sign, which happens when $2y$ is moved across the equals sign without changing its sign.

19. If 20% salt solution is to be mixed with 40% salt to form a mixture of 30% salt solution of 600 liters, then how much of the 40% salt solution is needed? (1)
- A. 100 liters B. 200 liters
- C. ✓ 300 liters D. 400 liters

Answer: C

Let y be the litres of 40% solution, so the other $600 - y$ litres come from the 20% solution. The salt must balance: $0.2(600 - y) + 0.4y = 0.3(600)$. That gives $120 - 0.2y + 0.4y = 180$, so $0.2y = 60$ and $y = 300$ litres. Option D is tempting if you feel the mixture should lean towards the stronger solution, but 30% sits exactly halfway between 20% and 40%, so the two parts are equal.

20. For any $n \times n$ matrix A , which one is true? (1)
- A. If B is obtained by interchanging two rows of A , then $\det(A) = \det(B)$
 - B. ✓ If A is invertible, then $\det(A) = 1/\det(A^{-1})$
 - C. $\det(A) = -\det(A^t)$
 - D. If k is scalar, $\det(kA) = k \det(A)$

Answer: B

If A is invertible then $AA^{-1} = I$. Determinants multiply, so $\det(A) \det(A^{-1}) = \det(I) = 1$, and dividing gives $\det(A) = \frac{1}{\det(A^{-1})}$. Option D is the tempting one, because pulling a common factor out of a determinant feels like pulling it out of a bracket. A scalar k multiplies every one of the n rows, so $\det(kA) = k^n \det(A)$, not $k \det(A)$.

21. For what value of x is the matrix $A = \begin{bmatrix} x & -3 & x \\ -1 & 0 & 2 \\ 2 & 1 & -5 \end{bmatrix}$ non-invertible (singular)? (1)
- A. ✓ 1 B. -1
C. 2 D. -2

Answer: A

A matrix has no inverse exactly when its determinant is 0. Expand along the first row: $\det A = x(0(-5) - 2(1)) - (-3)((-1)(-5) - 2(2)) + x((-1)(1) - 0(2))$. That is $x(-2) + 3(5 - 4) + x(-1) = -2x + 3 - x = 3 - 3x$. Setting $3 - 3x = 0$ gives $x = 1$. Option B comes from a sign slip in the middle term: the entry -3 carries a cofactor sign of minus, and the two minuses cancel to give $+3$.

- 22.** The 3×3 system $AX = B$ has solution $(2, b, -4)$. If $\det(A) = -2$ and the determinant of the matrix obtained by replacing the second column of A by B is $1/4$, then what is b ?
- A. ✓ **-1/8** B. -8
C. -1/2 D. -2

Answer: A

Cramer's rule writes each unknown as a ratio of two determinants. The unknown b sits in the second position, so $b = \frac{\det(A_2)}{\det(A)}$, where A_2 is A with its second column swapped for B . Putting the numbers in: $b = \frac{1/4}{-2} = -\frac{1}{8}$. Option B is the same two numbers divided the other way round. The replaced determinant always goes on top and $\det(A)$ underneath.

23. Let $\{a_n\}$ be arithmetic with $a_3=7$ and common difference -4 , then the n th term (general term) is: (1)

- A. $13-2n$ B. $16-3n$
C. ✓ **$19-4n$** D. $22-5n$

Answer: C

In an arithmetic sequence every term is the previous one plus the common difference, so counting from the third term, $a_n = a_3 + (n-3)d$. With $a_3 = 7$ and $d = -4$: $a_n = 7 + (n-3)(-4) = 7 - 4n + 12 = 19 - 4n$. Be careful with the checking here, because all four options give 7 when $n = 3$, so testing that one term settles nothing. What separates them is the size of the step: $19 - 4n$ falls by 4 each time, which matches $d = -4$, while option D falls by 5.

24. A certain meeting hall has rows with 27,31,35,39,... seats, last row 107 seats. Total number of seats? (1)

- A. ✓ **1407** B. 1427
C. 1307 D. 1327

Answer: A

The seat counts form an arithmetic sequence starting at 27 with a common difference of 4. First find how many rows there are: $107 = 27 + 4(n-1)$ gives $80 = 4(n-1)$, so $n = 21$. The sum of an arithmetic sequence is the number of terms times the average of the first and last term: $S = 21 \times \frac{27+107}{2} = 21 \times 67 = 1407$. The common trap is the row count. Solving $107 = 27 + 4n$ instead gives 20 rows and a total of $20 \times 67 = 1340$, which is not on the list at all, and that missing value is your warning that the count was off by one.

25. What is the local minimum value of $f(x)=x^3-12x+1$? (1)

- A. -24 B. -20
C. ✓ **-15** D. -14

Answer: C

Differentiate: $f'(x) = 3x^2 - 12$. Setting it to zero gives $x^2 = 4$, so the turning points are at $x = 2$ and $x = -2$. The second derivative is $f''(x) = 6x$, which is positive at $x = 2$, so $x = 2$ is the local minimum. Its value is $f(2) = 8 - 24 + 1 = -15$. Option A is what you get from the $-12x$ piece on its own at $x = 2$, leaving out the x^3 and the $+1$.

26. Let $f(x)=6x/(a-x)$. For what value of a is $f'(-2a)=1/4$? (1)

- A. $3/8$ B. ✓ **$8/3$**
C. $5/4$ D. $4/5$

Answer: B

Use the quotient rule on $f(x) = \frac{6x}{a-x}$: $f'(x) = \frac{6(a-x) - 6x(-1)}{(a-x)^2} = \frac{6a - 6x + 6x}{(a-x)^2} = \frac{6a}{(a-x)^2}$. Now put $x = -2a$. The bottom becomes $(a+2a)^2 = 9a^2$, so $f'(-2a) = \frac{6a}{9a^2} = \frac{2}{3a}$. Setting $\frac{2}{3a} = \frac{1}{4}$ gives $3a = 8$, so $a = \frac{8}{3}$. Option A is the reciprocal of the answer, which comes from cross multiplying the wrong way at that last step.

27. The time rate of change of the radius of a sphere is $1/(2\pi)$ cm/sec when radius is 5 cm. What is the rate of change of surface area? (1)

- A. $10 \text{ cm}^2/\text{sec}$ B. ✓ **$20 \text{ cm}^2/\text{sec}$**
C. $30 \text{ cm}^2/\text{sec}$ D. $40 \text{ cm}^2/\text{sec}$

Answer: B

The surface area of a sphere is $S = 4\pi r^2$. Differentiate both sides with respect to time and use the chain rule: $\frac{dS}{dt} = 8\pi r \frac{dr}{dt}$. Put in $r = 5$ and $\frac{dr}{dt} = \frac{1}{2\pi}$: $\frac{dS}{dt} = 8\pi(5) \left(\frac{1}{2\pi}\right) = \frac{40\pi}{2\pi} = 20 \text{ cm}^2 \text{ per second}$. Option A is exactly half, which is what you get if $4\pi r^2$ is differentiated as $4\pi r$ and the 2 is not brought down from the square.

28. What is the area of the region bounded by $f(x)=x^2-3x+2$ and the x -axis on $[0,2]$?

(1)

A. ✓ 1

B. 3/4

C. 3/2

D. -3/4

Answer: A

Factorise first: $x^2 - 3x + 2 = (x - 1)(x - 2)$, so the curve meets the x -axis at $x = 1$ and $x = 2$. On $[0, 1]$ the curve is above the axis and on $[1, 2]$ it is below, so the two pieces have to be measured separately and both counted as positive. With $F(x) = \frac{x^3}{3} - \frac{3x^2}{2} + 2x$, the first piece is $F(1) - F(0) = \frac{5}{6}$ and the second is $F(2) - F(1) = -\frac{1}{6}$, whose size is $\frac{1}{6}$. The area is $\frac{5}{6} + \frac{1}{6} = 1$. Option D is negative, and an area is never negative. It is a reminder that the piece below the axis must have its sign flipped before you add.

29. The interquartile range of the data 7,3,5,1,6,1,6,8 is

(1)

A. ✓ 4.5

B. 4

C. 3.5

D. 3

Answer: A

Sort the values first: 1, 1, 3, 5, 6, 6, 7, 8. There are 8 numbers, so the lower half is 1, 1, 3, 5 and the upper half is 6, 6, 7, 8. The first quartile is the middle of the lower half, $\frac{1+3}{2} = 2$, and the third quartile is the middle of the upper half, $\frac{6+7}{2} = 6.5$. The interquartile range is $6.5 - 2 = 4.5$. The usual mistake is to read the quartiles off the list in the order it was given. Sorting is always the first step.

END OF THE MARKING KEY

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