

2021 AMC 12B (November) Problems and Answer Key *

PROFESSOR CHEN EDUCATION PALACE

1. (2021 AMC 10B (Nov) Problem 1)(2021 AMC 12B (Nov) Problem 1)

What is the value of $1234 + 2341 + 3412 + 4123$?

- A. 10,000 B. 10,010 C. 10,110 D. 11,000 E. 11,110

Solution: (E)

2. (2021 AMC 10B (Nov) Problem 2)(2021 AMC 12B (Nov) Problem 2)

What is the area of the shaded figure shown below?

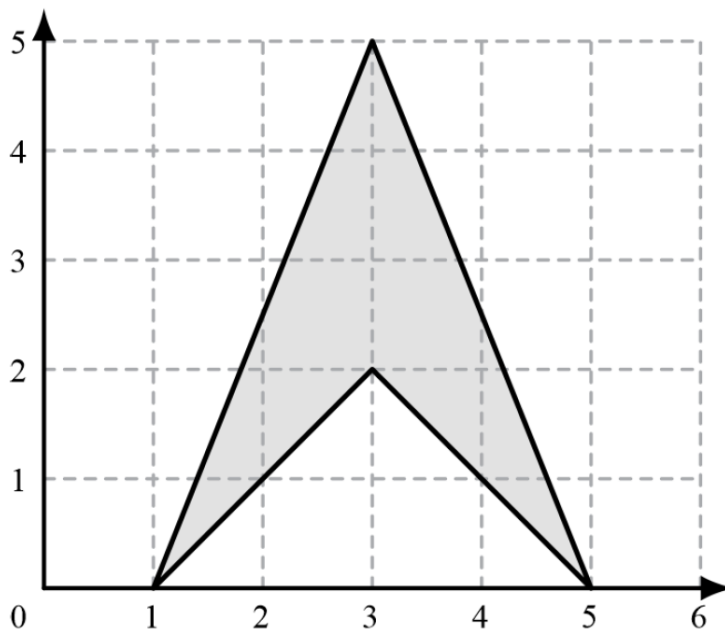


Figure 1: 2021 AMC 12B (Nov) Problem 2

- A. 4 B. 6 C. 8 D. 10 E. 12

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Solution: (B)

3. (2021 AMC 10B (Nov) Problem 4)(2021 AMC 12B (Nov) Problem 3)

At noon on a certain day, Minneapolis is N degrees warmer than St. Louis. At 4:00 the temperature in Minneapolis has fallen by 5 degrees while the temperature in St. Louis has risen by 3 degrees, at which time the temperatures in the two cities differ by 2 degrees. What is the product of all possible values of N ?

A. 10 B. 30 C. 60 D. 100 E. 120

Solution: (C)

4. (2021 AMC 10B (Nov) Problem 5)(2021 AMC 12B (Nov) Problem 4)

Let

$$n = 8^{2022}.$$

Which of the following is equal to $\frac{n}{4}$?

A. 4^{1010} B. 2^{2022} C. 8^{2018} D. 4^{3031} E. 4^{3032}

Solution: (E)

5. (2021 AMC 10B (Nov) Problem 7)(2021 AMC 12B (Nov) Problem 5)

Call a fraction $\frac{a}{b}$, not necessarily in simplest form, *special* if a and b are positive integers whose sum is 15. How many distinct integers can be written as the sum of two, not necessarily different, special fractions?

A. 9 B. 10 C. 11 D. 12 E. 13

Solution: (C)

6. (2021 AMC 10B (Nov) Problem 8)(2021 AMC 12B (Nov) Problem 6)

The greatest prime number that is a divisor of 16,384 is 2 because $16,384 = 2^{14}$. What is the sum of the digits of the greatest prime number that is a divisor of 16,383?

A. 3 B. 7 C. 10 D. 16 E. 22

Solution: (C)

7. (2021 AMC 10B (Nov) Problem 12)(2021 AMC 12B (Nov) Problem 7)

Which of the following conditions is sufficient to guarantee that integers x , y , and z satisfy the equation

$$x(x - y) + y(y - z) + z(z - x) = 1?$$

- A. $x > y$ and $y = z$ B. $x = y - 1$ and $y = z - 1$ C. $x = z + 1$ and $y = x + 1$
D. $x = z$ and $y - 1 = x$ E. $x + y + z = 1$

Solution: (D)

8. (2021 AMC 12B (Nov) Problem 8)

The product of the lengths of the two congruent sides of an obtuse isosceles triangle is equal to the product of the base and twice the triangle's height to the base. What is the measure, in degrees, of the vertex angle of this triangle?

- A. 105 B. 120 C. 135 D. 150 E. 165

Solution: (D)

9. (2021 AMC 12B (Nov) Problem 9)

Triangle ABC is equilateral with side length 6. Suppose that O is the center of the inscribed circle of this triangle. What is the area of the circle passing through A , O , and C ?

- A. 9π B. 12π C. 18π D. 24π E. 27π

Solution: (B)

10. (2021 AMC 12B (Nov) Problem 10)

What is the sum of all possible values of t between 0 and 360 such that the triangle in the coordinate plane whose vertices are $(\cos 40^\circ, \sin 40^\circ)$, $(\cos 60^\circ, \sin 60^\circ)$, and $(\cos t^\circ, \sin t^\circ)$ is isosceles?

- A. 100 B. 150 C. 330 D. 360 E. 380

Solution: (E)

11. (2021 AMC 10B (Nov) Problem 14)(2021 AMC 12B (Nov) Problem 11)

Una rolls 6 standard 6-sided dice simultaneously and calculates the product of the 6 numbers obtained. What is the probability that the product is divisible by 4?

- A. $\frac{3}{4}$ B. $\frac{57}{64}$ C. $\frac{59}{64}$ D. $\frac{187}{192}$ E. $\frac{63}{64}$

Solution: (C)

12. (2021 AMC 12B (Nov) Problem 12)

For n a positive integer, let $f(n)$ be the quotient obtained when the sum of all positive divisors of n is divided by n . For example,

$$f(14) = (1 + 2 + 7 + 14) \div 14 = \frac{12}{7}.$$

What is $f(768) - f(384)$?

- A. $\frac{1}{768}$ B. $\frac{1}{192}$ C. 1 D. $\frac{4}{3}$ E. $\frac{8}{3}$

Solution: (B)

13. (2021 AMC 12B (Nov) Problem 13)

Let

$$c = \frac{2\pi}{11}.$$

What is the value of

$$\frac{\sin 3c \cdot \sin 6c \cdot \sin 9c \cdot \sin 12c \cdot \sin 15c}{\sin c \cdot \sin 2c \cdot \sin 3c \cdot \sin 4c \cdot \sin 5c}?$$

- A. -1 B. $-\frac{\sqrt{11}}{5}$ C. $\frac{\sqrt{11}}{5}$ D. $\frac{10}{11}$ E. 1

Solution: (E)

14. (2021 AMC 12B (Nov) Problem 14)

Suppose that $P(z)$, $Q(z)$, and $R(z)$ are polynomials with real coefficients, having degrees 2, 3, and 6, respectively, and constant terms 1, 2, and 3, respectively. Let N be the number of distinct complex numbers z that satisfy the equation

$$P(z) \cdot Q(z) = R(z).$$

What is the minimum possible value of N ?

- A. 0 B. 1 C. 2 D. 3 E. 5

Solution: (B)

15. (2021 AMC 10B (Nov) Problem 18)(2021 AMC 12B (Nov) Problem 15)

Three identical square sheets of paper each with side length 6 are stacked on top of each other. The middle sheet is rotated clockwise 30° about its center and the top sheet is rotated clockwise 60° about its center, resulting in the 24-sided polygon shown in the figure below. The area of this polygon can be expressed in the form $a - b\sqrt{c}$, where a , b , and c are positive integers, and c is not divisible by the square of any prime. What is $a + b + c$?

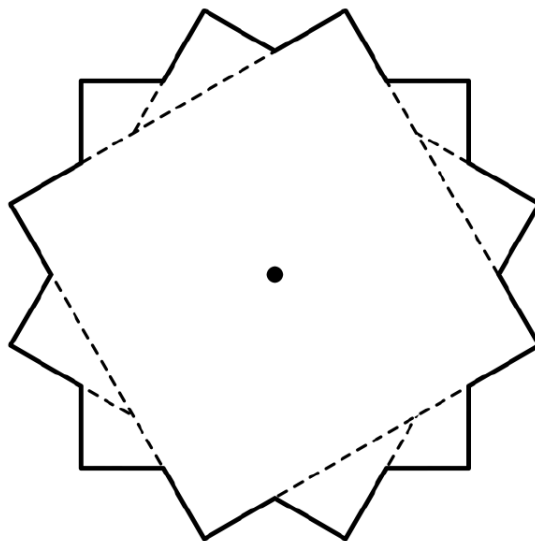


Figure 2: 2021 AMC 12B (Nov) Problem 15, Solution

- A. 75 B. 93 C. 96 D. 129 E. 147

Solution: (E)

16. (2021 AMC 12B (Nov) Problem 16)

Suppose a , b , and c are positive integers such that

$$a + b + c = 23$$

and

$$\gcd(a, b) + \gcd(b, c) + \gcd(c, a) = 9.$$

What is the sum of all possible distinct values of $a^2 + b^2 + c^2$?

- A. 259 B. 438 C. 516 D. 625 E. 687

Solution: (B)

17. (2021 AMC 12B (Nov) Problem 17)

A bug starts at a vertex of a grid made up of equilateral triangles of side length 1. At each step the bug moves in one of the 6 possible directions along the grid lines randomly and independently with equal probability. What is the probability that after 5 moves the bug never will have been more than 1 unit away from the starting position?

- A. $\frac{13}{108}$ B. $\frac{7}{54}$ C. $\frac{29}{216}$ D. $\frac{4}{27}$ E. $\frac{1}{6}$

Solution: (A)

18. (2021 AMC 12B (Nov) Problem 18)

Set $u_0 = \frac{1}{4}$, and for $k \geq 0$ let u_{k+1} be determined by the recurrence

$$u_{k+1} = 2u_k - 2u_k^2.$$

This sequence tends to a limit; call it L . What is the least value of k such that

$$|u_k - L| \leq \frac{1}{2^{1000}}?$$

- A. 10 B. 97 C. 123 D. 329 E. 401

Solution: (A)

19. (2021 AMC 10B (Nov) Problem 21)(2021 AMC 12B (Nov) Problem 19)

Regular polygons with 5, 6, 7, and 8 sides are inscribed in the same circle. No two of the polygons share a vertex, and no three of their sides intersect at a common point. At how many points inside the circle do two of their sides intersect?

- A. 52 B. 56 C. 60 D. 64 E. 68

Solution: (E)

20. (2021 AMC 10B (Nov) Problem 24)(2021 AMC 12B (Nov) Problem 20)

A cube is constructed from 4 white unit cubes and 4 blue unit cubes. How many different ways are there to construct the $2 \times 2 \times 2$ cube using these smaller cubes? (Two constructions are considered the same if one can be rotated to match the other.)

- A. 7 B. 8 C. 9 D. 10 E. 11

Solution: (A)

21. (2021 AMC 12B (Nov) Problem 21)

For real numbers x , let

$$P(x) = 1 + \cos(x) + i \sin(x) - \cos(2x) - i \sin(2x) + \cos(3x) + i \sin(3x),$$

where $i = \sqrt{-1}$. For how many values of x with $0 \leq x < 2\pi$ does

$$P(x) = 0?$$

- A. 0 B. 1 C. 2 D. 3 E. 4

Solution: (A)

22. (2021 AMC 12B (Nov) Problem 22)

Right triangle ABC has side lengths $BC = 6$, $AC = 8$, and $AB = 10$. A circle centered at O is tangent to line BC at B and passes through A . A circle centered at P is tangent to line AC at A and passes through B . What is OP ?

- A. $\frac{23}{8}$ B. $\frac{29}{10}$ C. $\frac{35}{12}$ D. $\frac{73}{25}$ E. 3

Solution: (C)

23. (2021 AMC 12B (Nov) Problem 23)

What is the average number of pairs of consecutive integers in a randomly selected subset of 5 distinct integers chosen from the set $\{1, 2, 3, \dots, 30\}$? (For example, the set $\{1, 17, 18, 19, 30\}$ has 2 pairs of consecutive integers.)

- A. $\frac{2}{3}$ B. $\frac{29}{36}$ C. $\frac{5}{6}$ D. $\frac{29}{30}$ E. 1

Solution: (A)

24. (2021 AMC 12B (Nov) Problem 24)

Triangle ABC has side lengths $AB = 11$, $BC = 24$, and $CA = 20$. The bisector of $\angle BAC$ intersects \overline{BC} at point D and intersects the circumcircle of $\triangle ABC$ at point $E \neq A$. The circumcircle of $\triangle BED$ intersects the line AB at points B and $F \neq B$. What is CF ?

A. 28 B. $20\sqrt{2}$ C. 30 D. 32 E. $20\sqrt{3}$

Solution: (C)

25. (2021 AMC 12B (Nov) Problem 25)

For n a positive integer, let $R(n)$ be the sum of remainders when n is divided by 2, 3, 4, 5, 6, 7, 8, 9, and 10. For example,

$$R(15) = 1 + 0 + 3 + 0 + 3 + 1 + 7 + 6 + 5 = 26.$$

How many two-digit positive integers n satisfy $R(n) = R(n+1)$?

A. 0 B. 1 C. 2 D. 3 E. 4

Solution: (C)