

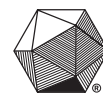
2016
AMC 12A

DO NOT OPEN UNTIL TUESDAY, FEBRUARY 2, 2016

****Administration On An Earlier Date Will Disqualify Your School's Results****

1. All information (Rules and Instructions) needed to administer this exam is contained in the **TEACHERS' MANUAL**. PLEASE READ THE MANUAL BEFORE FEBRUARY 2, 2016.
2. Your **PRINCIPAL** or **VICE-PRINCIPAL** must verify on the **AMC 12 CERTIFICATION FORM** (found in the Teachers' Manual) that you followed all rules associated with the conduct of the exam.
3. The Answer Forms must be mailed by trackable mail to the AMC office no later than 24 hours following the exam.
4. *The publication, reproduction or communication of the problems or solutions for this contest during the period when students are eligible to participate seriously jeopardizes the integrity of the results. Dissemination at any time via copier, telephone, email, internet, or media of any type is a violation of the competition rules.*

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MAA100
MATHEMATICAL ASSOCIATION OF AMERICA
CELEBRATING A CENTURY OF ADVANCING MATHEMATICS

American Mathematics Competitions

67th Annual

AMC 12A

American Mathematics Contest 12A

Tuesday, February 2, 2016

INSTRUCTIONS

1. DO NOT OPEN THIS BOOKLET UNTIL YOUR PROCTOR TELLS YOU.
2. This is a 25-question multiple-choice test. Each question is followed by answers marked A, B, C, D, and E. Only one of these is correct.
3. Mark your answer to each problem on the AMC 12 Answer Form with a #2 pencil. Check the blackened circles for accuracy and erase errors and stray marks completely. Only answers properly marked on the answer form will be graded. **No copies.**
4. **SCORING:** You will receive 6 points for each correct answer, 1.5 points for each problem left unanswered, and 0 points for each incorrect answer.
5. No aids are permitted other than scratch paper, graph paper, rulers, compass, protractors, and erasers. No calculators, smartwatches, or computing devices are allowed. No problems on the test will require the use of a calculator.
6. Figures are not necessarily drawn to scale.
7. Before beginning the test, your proctor will ask you to record certain information on the answer form.
8. When your proctor gives the signal, begin working on the problems. You will have **75 minutes** to complete the test.
9. When you finish the exam, *sign your name* in the space provided on the Answer Form.

The Committee on the American Mathematics Competitions (CAMC) reserves the right to re-examine students before deciding whether to grant official status to their scores. The CAMC also reserves the right to disqualify all scores from a school if it is determined that the required security procedures were not followed. *Students who score well on this AMC 12 will be invited to take the 34th annual American Invitational Mathematics Examination (AIME) on Thursday, March 3, 2016 or Wednesday, March 16, 2016. More details about the AIME are on the back page of this test booklet.*

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1. What is the value of $\frac{11! - 10!}{9!}$?
 (A) 99 (B) 100 (C) 110 (D) 121 (E) 132
2. For what value of x does $10^x \cdot 100^{2x} = 1000^5$?
 (A) 1 (B) 2 (C) 3 (D) 4 (E) 5
3. The remainder function can be defined for all real numbers x and y with $y \neq 0$ by

$$\text{rem}(x, y) = x - y \left\lfloor \frac{x}{y} \right\rfloor,$$

where $\left\lfloor \frac{x}{y} \right\rfloor$ denotes the greatest integer less than or equal to $\frac{x}{y}$. What is the value of $\text{rem}\left(\frac{3}{8}, -\frac{2}{5}\right)$?

- (A) $-\frac{3}{8}$ (B) $-\frac{1}{40}$ (C) 0 (D) $\frac{3}{8}$ (E) $\frac{31}{40}$
4. The mean, median, and mode of the 7 data values 60, 100, x , 40, 50, 200, 90 are all equal to x . What is the value of x ?
 (A) 50 (B) 60 (C) 75 (D) 90 (E) 100
5. Goldbach's conjecture states that every even integer greater than 2 can be written as the sum of two prime numbers (for example, $2016 = 13 + 2003$). So far, no one has been able to prove that the conjecture is true, and no one has found a counterexample to show that the conjecture is false. What would a counterexample consist of?

(A) an odd integer greater than 2 that can be written as the sum of two prime numbers

(B) an odd integer greater than 2 that cannot be written as the sum of two prime numbers

(C) an even integer greater than 2 that can be written as the sum of two numbers that are not prime

(D) an even integer greater than 2 that can be written as the sum of two prime numbers

(E) an even integer greater than 2 that cannot be written as the sum of two prime numbers



American Mathematics Competitions

WRITE TO US!

Correspondence about the problems and solutions for this AMC 12 and orders for publications should be addressed to:

MAA American Mathematics Competitions

PO Box 471

Annapolis Junction, MD 20701

Phone 800.527.3690 | Fax 240.396.5647 | amcinfo@maa.org

The problems and solutions for this AMC 12 were prepared by MAA's Subcommittee on the AMC10/AMC12 Exams, under the direction of the co-chairs Jerrold W. Grossman and Silvia Fernandez.

2015 AIME

The 34th annual AIME will be held on Thursday, March 3, 2016, with the alternate on Wednesday, March 16, 2016. It is a 15-question, 3-hour, integer-answer exam. You will be invited to participate if you achieve a high score on this contest. Top-scoring students on the AMC 10/12/AIME will be selected to take the 45th Annual USA Mathematical Olympiad (USAMO) on April 19–20, 2016. The best way to prepare for the AIME and USAMO is to study previous exams. Copies may be ordered as indicated below.

PUBLICATIONS

A complete listing of current publications, with ordering instructions, is at our web site:
www.maa.org/amc

22. How many ordered triples (x, y, z) of positive integers satisfy $\text{lcm}(x, y) = 72$, $\text{lcm}(x, z) = 600$, and $\text{lcm}(y, z) = 900$?

(A) 15 (B) 16 (C) 24 (D) 27 (E) 64

23. Three numbers in the interval $[0, 1]$ are chosen independently and at random. What is the probability that the chosen numbers are the side lengths of a triangle with positive area?

(A) $\frac{1}{6}$ (B) $\frac{1}{3}$ (C) $\frac{1}{2}$ (D) $\frac{2}{3}$ (E) $\frac{5}{6}$

24. There is a smallest positive real number a such that there exists a positive real number b such that all the roots of the polynomial $x^3 - ax^2 + bx - a$ are real. In fact, for this value of a the value of b is unique. What is this value of b ?

(A) 8 (B) 9 (C) 10 (D) 11 (E) 12

25. Let k be a positive integer. Bernardo and Silvia take turns writing and erasing numbers on a blackboard as follows: Bernardo starts by writing the smallest perfect square with $k + 1$ digits. Every time Bernardo writes a number, Silvia erases the last k digits of it. Bernardo then writes the next perfect square, Silvia erases the last k digits of it, and this process continues until the last two numbers that remain on the board differ by at least 2. Let $f(k)$ be the smallest positive integer not written on the board. For example, if $k = 1$, then the numbers that Bernardo writes are 16, 25, 36, 49, and 64, and the numbers showing on the board after Silvia erases are 1, 2, 3, 4, and 6, and thus $f(1) = 5$. What is the sum of the digits of $f(2) + f(4) + f(6) + \cdots + f(2016)$?

(A) 7986 (B) 8002 (C) 8030 (D) 8048 (E) 8064

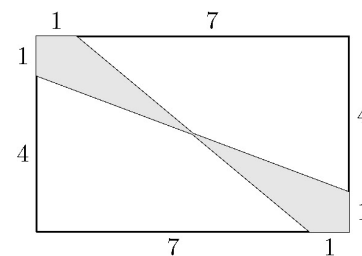
6. A triangular array of 2016 coins has 1 coin in the first row, 2 coins in the second row, 3 coins in the third row, and so on up to N coins in the N th row. What is the sum of the digits of N ?

(A) 6 (B) 7 (C) 8 (D) 9 (E) 10

7. Which of these describes the graph of $x^2(x + y + 1) = y^2(x + y + 1)$?

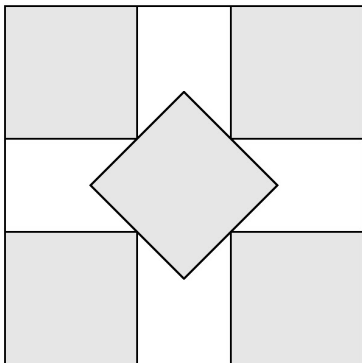
(A) two parallel lines
 (B) two intersecting lines
 (C) three lines that all pass through a common point
 (D) three lines that do not all pass through a common point
 (E) a line and a parabola

8. What is the area of the shaded region of the given 8×5 rectangle?



(A) $4\frac{3}{4}$ (B) 5 (C) $5\frac{1}{4}$ (D) $6\frac{1}{2}$ (E) 8

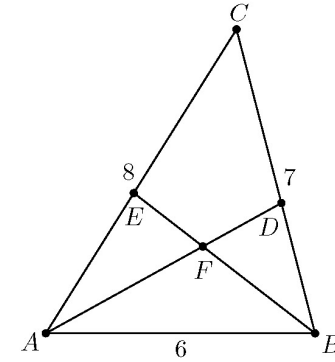
9. The five small shaded squares inside this unit square are congruent and have disjoint interiors. The midpoint of each side of the middle square coincides with one of the vertices of the other four small squares as shown. The common side length is $\frac{a-\sqrt{2}}{b}$, where a and b are positive integers. What is $a + b$?



- (A) 7 (B) 8 (C) 9 (D) 10 (E) 11
10. Five friends sat in a movie theater in a row containing 5 seats, numbered 1 to 5 from left to right. (The directions “left” and “right” are from the point of view of the people as they sit in the seats.) During the movie Ada went to the lobby to get some popcorn. When she returned, she found that Bea had moved two seats to the right, Ceci had moved one seat to the left, and Dee and Edie had switched seats, leaving an end seat for Ada. In which seat had Ada been sitting before she got up?
- (A) 1 (B) 2 (C) 3 (D) 4 (E) 5
11. Each of the 100 students in a certain summer camp can either sing, dance, or act. Some students have more than one talent, but no student has all three talents. There are 42 students who cannot sing, 65 students who cannot dance, and 29 students who cannot act. How many students have two of these talents?
- (A) 16 (B) 25 (C) 36 (D) 49 (E) 64

16. The graphs of $y = \log_3 x$, $y = \log_x 3$, $y = \log_{\frac{1}{3}} x$, and $y = \log_x \frac{1}{3}$ are plotted on the same set of axes. How many points in the plane with positive x -coordinates lie on two or more of the graphs?
- (A) 2 (B) 3 (C) 4 (D) 5 (E) 6
17. Let $ABCD$ be a square. Let E , F , G , and H be the centers, respectively, of equilateral triangles with bases \overline{AB} , \overline{BC} , \overline{CD} , and \overline{DA} , each exterior to the square. What is the ratio of the area of square $EFGH$ to the area of square $ABCD$?
- (A) 1 (B) $\frac{2+\sqrt{3}}{3}$ (C) $\sqrt{2}$ (D) $\frac{\sqrt{2}+\sqrt{3}}{2}$ (E) $\sqrt{3}$
18. For some positive integer n , the number $110n^3$ has 110 positive integer divisors, including 1 and the number $110n^3$. How many positive integer divisors does the number $81n^4$ have?
- (A) 110 (B) 191 (C) 261 (D) 325 (E) 425
19. Jerry starts at 0 on the real number line. He tosses a fair coin 8 times. When he gets heads, he moves 1 unit in the positive direction; when he gets tails, he moves 1 unit in the negative direction. The probability that he reaches 4 at some time during this process is $\frac{a}{b}$, where a and b are relatively prime positive integers. What is $a + b$? (For example, he succeeds if his sequence of tosses is HTHHHHHH.)
- (A) 69 (B) 151 (C) 257 (D) 293 (E) 313
20. A binary operation \diamond has the properties that $a \diamond (b \diamond c) = (a \diamond b) \cdot c$ and that $a \diamond a = 1$ for all nonzero real numbers a , b , and c . (Here the dot \cdot represents the usual multiplication operation.) The solution to the equation $2016 \diamond (6 \diamond x) = 100$ can be written as $\frac{p}{q}$, where p and q are relatively prime positive integers. What is $p + q$?
- (A) 109 (B) 201 (C) 301 (D) 3049 (E) 33,601
21. A quadrilateral is inscribed in a circle of radius $200\sqrt{2}$. Three of the sides of this quadrilateral have length 200. What is the length of its fourth side?
- (A) 200 (B) $200\sqrt{2}$ (C) $200\sqrt{3}$ (D) $300\sqrt{2}$ (E) 500

12. In $\triangle ABC$, $AB = 6$, $BC = 7$, and $CA = 8$. Point D lies on \overline{BC} , and \overline{AD} bisects $\angle BAC$. Point E lies on \overline{AC} , and \overline{BE} bisects $\angle ABC$. The bisectors intersect at F . What is the ratio $AF : FD$?



(A) 3 : 2 (B) 5 : 3 (C) 2 : 1 (D) 7 : 3 (E) 5 : 2

13. Let N be a positive multiple of 5. One red ball and N green balls are arranged in a line in random order. Let $P(N)$ be the probability that at least $\frac{3}{5}$ of the green balls are on the same side of the red ball. Observe that $P(5) = 1$ and that $P(N)$ approaches $\frac{4}{5}$ as N grows large. What is the sum of the digits of the least value of N such that $P(N) < \frac{321}{400}$?

(A) 12 (B) 14 (C) 16 (D) 18 (E) 20

14. Each vertex of a cube is to be labeled with an integer from 1 through 8, with each integer being used once, in such a way that the sum of the four numbers on the vertices of a face is the same for each face. Arrangements that can be obtained from each other through rotations of the cube are considered to be the same. How many different arrangements are possible?

(A) 1 (B) 3 (C) 6 (D) 12 (E) 24

15. Circles with centers P , Q , and R , having radii 1, 2, and 3, respectively, lie on the same side of line l and are tangent to l at P' , Q' , and R' , respectively, with Q' between P' and R' . The circle with center Q is externally tangent to each of the other two circles. What is the area of $\triangle PQR$?

(A) 0 (B) $\sqrt{\frac{2}{3}}$ (C) 1 (D) $\sqrt{6} - \sqrt{2}$ (E) $\sqrt{\frac{3}{2}}$