2001 AMC 12 Problems/Problem 1

The following problem is from both the 2001 AMC 12 #1 and 2001 AMC 10 #3, so both problems redirect to this page.

Problem

The sum of two numbers is S. Suppose 3 is added to each number and then each of the resulting numbers is doubled. What is the sum of the final two numbers?

$\text{(A)}\ 2S + 3 \qquad \text{(B)}\ 3S + 2 \qquad \text{(C)}\ 3S + 6 \qquad \text{(D)}\ 2S + 6 \qquad \text{(E)}\ 2S + 12$

Solution

Suppose the two numbers are a and b, with $a+b=S$. Then the desired sum is $2(a+3)+2(b+3)=2(a+b)+12=2S+12$, which is answer $\boxed{\text{(E)}}$.

See also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
Preceded by First question	Followed by Problem 2
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2001 AMC 10 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=43&year=2001))	
Preceded by Problem 2	Followed by Problem 4
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All AMC 10 Problems and Solutions	

2001 AMC 12 Problems/Problem 2

The following problem is from both the 2001 AMC 12 #2 and 2001 AMC 10 #6, so both problems redirect to this page.

Problem

Let $P(n)$ and $S(n)$ denote the product and the sum, respectively, of the digits of the integer n. For example, $P(23) = 6$ and $S(23) = 5$. Suppose N is a two-digit number such that $N = P(N) + S(N)$. What is the units digit of N?

$\text{(A)}\ 2\qquad \text{(B)}\ 3\qquad \text{(C)}\ 6\qquad \text{(D)}\ 8\qquad \text{(E)}\ 9$

Solution

Denote a and b as the tens and units digit of N, respectively. Then $N = 10a + b$. It follows that $10a + b = ab + a + b$, which implies that $9a = ab$. Since $a \neq 0$, $b = 9$. So the units digit of N is $\boxed{\text{(E)} 9}$.

See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
Preceded by Problem 1	Followed by Problem 3
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2001 AMC 10 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=43&year=2001))	
Preceded by Problem 5	Followed by Problem 7
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All AMC 10 Problems and Solutions	

2001 AMC 12 Problems/Problem 3

The following problem is from both the 2001 AMC 12 #3 and 2001 AMC 10 #9, so both problems redirect to this page.

Problem

The state income tax where Kristin lives is levied at the rate of $p\%$ of the first $\$28000$ of annual income plus $(p+2)\%$ of any amount above $\$28000$. Kristin noticed that the state income tax she paid amounted to $(p+0.25)\%$ of her annual income. What was her annual income?

$\text{(A)}\,\$28000 \qquad \text{(B)}\,\$32000 \qquad \text{(C)}\,\$35000 \qquad \text{(D)}\,\$42000 \qquad \text{(E)}\,\$56000$

Solution

Let the income amount be denoted by A.

We know that $\frac{A(p+.25)}{100}=\frac{28000p}{100}+\frac{(p+2)(A-28000)}{100}$.

We can now try to solve for A:

$(p+.25)A=28000p+Ap+2A-28000p-56000$

$.25A=2A-56000$

$A=32000$

So the answer is $\boxed{B}$

See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
Preceded by Problem 2	Followed by Problem 4
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2001 AMC 12 Problems/Problem 4

The following problem is from both the 2001 AMC 12 #4 and 2001 AMC 10 #16, so both problems redirect to this page.

Problem

The mean of three numbers is 10 more than the least of the numbers and 15 less than the greatest. The median of the three numbers is 5. What is their sum?

$\text{(A)}\ 5\qquad \text{(B)}\ 20\qquad \text{(C)}\ 25\qquad \text{(D)}\ 30\qquad \text{(E)}\ 36$

Solution

Let m be the mean of the three numbers. Then the least of the numbers is $m-10$ and the greatest is $m+15$. The middle of the three numbers is the median, 5. So $\frac{1}{3}[(m-10)+5+(m+15)]=m$, which implies that $m=10$. Hence, the sum of the three numbers is $3(10)=\boxed{\text{(D)} 30}$.

See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
Preceded by Problem 3	Followed by Problem 5
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2001 AMC 10 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=43&year=2001))	
Preceded by Problem 15	Followed by Problem 17
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All AMC 10 Problems and Solutions	

2001 AMC 12 Problems/Problem 5

Problem

What is the product of all positive odd integers less than 10000?

$\text{(A)}\ \dfrac{10000!}{(5000!)^2}\qquad \text{(B)}\ \dfrac{10000!}{2^{5000}}\qquad \text{(C)}\ \dfrac{9999!}{2^{5000}}\qquad \text{(D)}\ \dfrac{10000!}{2^{5000} \cdot 5000!}\qquad \text{(E)}\ \dfrac{5000!}{2^{5000}}$

Solution

$$1\cdot 3\cdot 5\cdots 9999 = \frac{1\cdot 2\cdot 3\cdot 4\cdots 10000}{2\cdot 4\cdot 6\cdots 10000} = \frac{10000!}{2^{5000}\cdot 1\cdot 2\cdot 3\cdots 5000} = \frac{10000!}{2^{5000}\cdot 5000!}$$

(D)

See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
Preceded by Problem 4	Followed by Problem 6
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All AMC 12 Problems and Solutions	

2001 AMC 12 Problems/Problem 6

The following problem is from both the 2001 AMC 12 #6 and 2001 AMC 10 #13, so both problems redirect to this page.

Problem

A telephone number has the form ABC-DEF-GHIJ, where each letter represents a different digit. The digits in each part of the number are in decreasing order; that is, $A > B > C$, $D > E > F$, and $G > H > I > J$. Furthermore, D, E, and F are consecutive even digits; G, H, I, and J are consecutive odd digits; and $A + B + C = 9$. Find A.

$\textbf{(A)}\ 4 \qquad \textbf{(B)}\ 5 \qquad \textbf{(C)}\ 6 \qquad \textbf{(D)}\ 7 \qquad \textbf{(E)}\ 8$

Solution

The last four digits GHIJ are either 9753 or 7531, and the other odd digit (1 or 9) must be A, B, or C. Since $A + B + C = 9$, that digit must be 1. Thus the sum of the two even digits in ABC is 8. DEF must be 864, 642, or 420, which respectively leave the pairs 2 and 0, 8 and 0, or 8 and 6, as the two even digits in ABC. Only 8 and 0 has sum 8, so ABC is 810, and the required first digit is $\boxed{\text{(E)}8}$.

See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
Preceded by Problem 5	Followed by Problem 7
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2001 AMC 10 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=43&year=2001))	
Preceded by Problem 12	Followed by Problem 14
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All AMC 10 Problems and Solutions	

2001 AMC 12 Problems/Problem 7

The following problem is from both the 2001 AMC 12 #7 and 2001 AMC 10A #14, so both problems redirect to this page.

Problem

A charity sells 140 benefit tickets for a total of 2001. Some tickets sell for full price (a whole dollar amount), and the rest sells for half price. How much money is raised by the full-price tickets?

$\text{(A) } \$782 \qquad \text{(B) } \$986 \qquad \text{(C) } \$1158 \qquad \text{(D) } \$1219 \qquad \text{(E) } \ \$1449$

Solution

Let's multiply ticket costs by 2, then the half price becomes an integer, and the charity sold 140 tickets worth a total of 4002 dollars.

Let h be the number of half price tickets, we then have $140-h$ full price tickets. The cost of $140-h$ full price tickets is equal to the cost of $280-2h$ half price tickets.

Hence we know that $h+(280-2h)=280-h$ half price tickets cost 4002 dollars. Then a single half price ticket costs $\frac{4002}{280-h}$ dollars, and this must be an integer. Thus $280-h$ must be a divisor of 4002. Keeping in mind that $0\leq h\leq 140$, we are looking for a divisor between 140 and 280, inclusive.

The prime factorization of 4002 is $4002=2\cdot 3\cdot 23\cdot 29$. We can easily find out that the only divisor of 4002 within the given range is $2\cdot 3\cdot 29=174$.

This gives us $280-h=174$, hence there were $h=106$ half price tickets and $140-h=34$ full price tickets.

In our modified setting (with prices multiplied by 2) the price of a half price ticket is $\frac{4002}{174}=23$. In the original setting this is the price of a full price ticket. Hence $23\cdot 34=\boxed{\text{(A)} 782}$ dollars are raised by the full price tickets.

See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
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All AMC 12 Problems and Solutions	

2001 AMC 10 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=43&year=2001))	
Preceded by Problem 13	Followed by Problem 15
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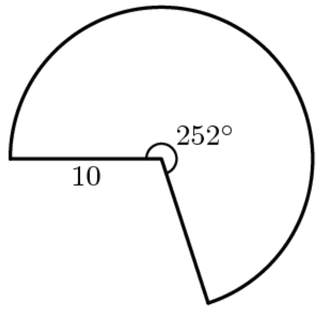
All AMC 10 Problems and Solutions	

2001 AMC 12 Problems/Problem 8

The following problem is from both the 2001 AMC 12 #8 and 2001 AMC 10 #17, so both problems redirect to this page.

Problem

Which of the cones listed below can be formed from a 252° sector of a circle of radius 10 by aligning the two straight sides?



$\textbf{(A)}$ A cone with slant height of 10 and radius 6

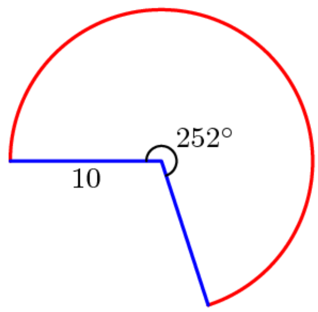
$\textbf{(B)}$ A cone with height of 10 and radius 6

$\textbf{(C)}$ A cone with slant height of 10 and radius 7

$\textbf{(D)}$ A cone with height of 10 and radius 7

$\textbf{(E)}$ A cone with slant height of 10 and radius 8

Solution



The blue lines will be joined together to form a single blue line on the surface of the cone, hence $\boxed{10}$ will be the $\boxed{\text{slant height}}$ of the cone.

The red line will form the circumference of the base. We can compute its length and use it to determine the radius.

The length of the red line is $\dfrac{252}{360}\cdot 2\pi \cdot 10 = 14\pi$. This is the circumference of a circle with radius $\boxed{7}$.

Therefore the correct answer is $\boxed{\text{C}}$.

See Also

2001 AMC 12 Problems/Problem 9

Problem

Let f be a function satisfying $f(xy) = \frac{f(x)}{y}$ for all positive real numbers x and y. If $f(500) = 3$, what is the value of $f(600)$?

$\text{(A)}\ 1 \qquad \text{(B)}\ 2 \qquad \text{(C)}\ \frac{5}{2} \qquad \text{(D)}\ 3 \qquad \text{(E)}\ \frac{18}{5}$

Solution

Letting $x = 500$ and $y = \frac{6}{5}$ in the given equation, we get $f(500 \cdot \frac{6}{5}) = \frac{3}{\frac{6}{5}} = \frac{5}{2}$, or $f(600) = \boxed{\textbf{C}\ \frac{5}{2}}$.

See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
Preceded by Problem 8	Followed by Problem 10
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All AMC 12 Problems and Solutions	

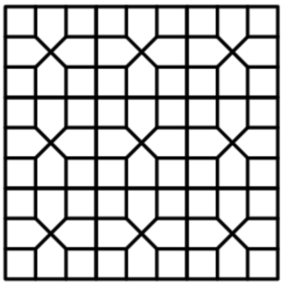
2001 AMC 12 Problems/Problem 10

The following problem is from both the 2001 AMC 12 #10 and 2001 AMC 10 #18, so both problems redirect to this page.

Problem

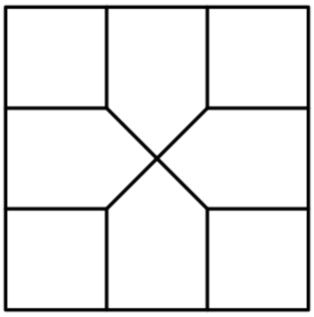
The plane is tiled by congruent squares and congruent pentagons as indicated. The percent of the plane that is enclosed by the pentagons is closest to

$\text{(A) } 50 \qquad \text{(B) } 52 \qquad \text{(C) } 54 \qquad \text{(D) } 56 \qquad \text{(E) } 58$



Solution

Consider any single tile:



If the side of the small square is a, then the area of the tile is $9a^2$, with $4a^2$ covered by squares and $5a^2$ by pentagons. Hence exactly $5/9$ of any tile are covered by pentagons, and therefore pentagons cover $5/9$ of the plane. When expressed as a percentage, this is $55.\overline{5}\%$, and the closest integer to this value is $\boxed{(D) 56}$.

See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
Preceded by Problem 9	Followed by Problem 11
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2001 AMC 12 Problems/Problem 11

The following problem is from both the 2001 AMC 12 #11 and 2001 AMC 10 #23, so both problems redirect to this page.

Contents

Problem

A box contains exactly five chips, three red and two white. Chips are randomly removed one at a time without replacement until all the red chips are drawn or all the white chips are drawn. What is the probability that the last chip drawn is white?

$$\text{(A) } \frac{3}{10} \qquad \text{(B) } \frac{2}{5} \qquad \text{(C) } \frac{1}{2} \qquad \text{(D) } \frac{3}{5} \qquad \text{(E) } \frac{7}{10}$$

Solution

Imagine that we draw all the chips in random order, i.e., we do not stop when the last chip of a color is drawn. To draw out all the white chips first, the last chip left must be red, and all previous chips can be drawn in any order. Since there are 3 red chips, the probability that the last chip of the five is red (and so also the probability that the last chip drawn is white) is $\boxed{\text{(D)} \frac{3}{5}}$.

Solution 2

We wish to arrange the letters: W,W, R, R, R such that R appears last. The probability of this occurring is simply $\frac{\binom{4}{2,2}}{\binom{5}{3,2}} = \boxed{\text{(D)} \frac{3}{5}}$

See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
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2001 AMC 12 Problems/Problem 12

The following problem is from both the 2001 AMC 12 #12 and 2001 AMC 10 #25, so both problems redirect to this page.

Problem

How many positive integers not exceeding 2001 are multiples of 3 or 4 but not 5?

$\text{(A) }768 \qquad \text{(B) }801 \qquad \text{(C) }934 \qquad \text{(D) }1067 \qquad \text{(E) }1167$

Solution

Out of the numbers 1 to 12 four are divisible by 3 and three by 4, counting 12 twice. Hence 6 out of these 12 numbers are multiples of 3 or 4.

The same is obviously true for the numbers $12k+1$ to $12k+12$ for any positive integer k.

Hence out of the numbers 1 to $60=5\cdot 12$ there are $5\cdot 6=30$ numbers that are divisible by 3 or 4. Out of these 30, the numbers 15, 20, 30, 40, 45 and 60 are divisible by 5. Therefore in the set $\{1,\dots,60\}$ there are precisely $30-6=24$ numbers that satisfy all criteria from the problem statement.

Again, the same is obviously true for the set $\{60k+1,\dots,60k+60\}$ for any positive integer k.

We have $1980/60=33$, hence there are $24\cdot 33=792$ good numbers among the numbers 1 to 1980. At this point we already know that the only answer that is still possible is $\boxed{\text{(B)}}$, as we only have 20 numbers left.

By examining the remaining 20 by hand we can easily find out that exactly 9 of them match all the criteria, giving us $792+9=\boxed{801}$ good numbers.

See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
Preceded by Problem 11	Followed by Problem 13
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2001 AMC 10 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=43&year=2001))	
Preceded by Problem 24	Followed by Last Question
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2001 AMC 12 Problems/Problem 13

Problem

The parabola with equation $p(x) = ax^2 + bx + c$ and vertex (h, k) is reflected about the line $y = k$. This results in the parabola with equation $q(x) = dx^2 + ex + f$. Which of the following equals $a + b + c + d + e + f$?

$\text{(A)}\ 2b \qquad \text{(B)}\ 2c \qquad \text{(C)}\ 2a + 2b \qquad \text{(D)}\ 2h \qquad \text{(E)}\ 2k$

Solution

We write $p(x)$ as $a(x-h)^2 + k$ (this is possible for any parabola). Then the reflection of $p(x)$ is $q(x) = -a(x-h)^2 + k$. Then we find $p(x) + q(x) = 2k$. Since $p(1) = a + b + c$ and $q(1) = d + e + f$, we have $a + b + c + d + e + f = 2k$, so the answer is $\boxed{\text{E}}$.

See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
Preceded by Problem 12	Followed by Problem 14
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2001 AMC 12 Problems/Problem 14

Problem

Given the nine-sided regular polygon $A_1A_2A_3A_4A_5A_6A_7A_8A_9$, how many distinct equilateral triangles in the plane of the polygon have at least two vertices in the set $\{A_1, A_2, \ldots, A_9\}$?

$\text{(A) }30 \qquad \text{(B) }36 \qquad \text{(C) }63 \qquad \text{(D) }66 \qquad \text{(E) }72$

Solution

Each of the $\binom{9}{2} = 36$ pairs of vertices determines two equilateral triangles, one on each side of the segment. This would give us 72 triangles. However, note that there are three equilateral triangles that have all three vertices among the vertices of the polygon. These are the triangles $A_1A_4A_7$, $A_2A_5A_8$, and $A_3A_6A_9$. We counted each of these three times (once for each side). Hence we overcounted by 2 for each of these triangles for a total of 6 overcounted, and the correct number of equilateral triangles is $72 - 6 = \boxed{66}$.

See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
Preceded by Problem 13	Followed by Problem 15
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All AMC 12 Problems and Solutions	

2001 AMC 12 Problems/Problem 15

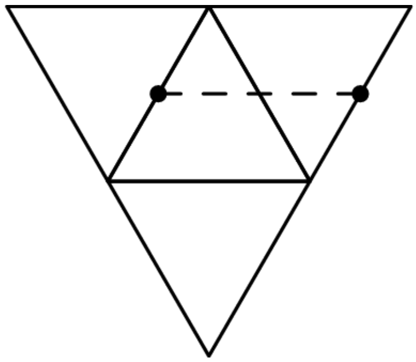
Problem

An insect lives on the surface of a regular tetrahedron with edges of length 1. It wishes to travel on the surface of the tetrahedron from the midpoint of one edge to the midpoint of the opposite edge. What is the length of the shortest such trip? (Note: Two edges of a tetrahedron are opposite if they have no common endpoint.)

$\text{(A)}\ \frac{1}{2}\sqrt{3} \qquad \text{(B)}\ 1 \qquad \text{(C)}\ \sqrt{2} \qquad \text{(D)}\ \frac{3}{2} \qquad \text{(E)}\ 2$

Solution

Given any path on the surface, we can unfold the surface into a plane to get a path of the same length in the plane. Consider the net of a tetrahedron in the picture below. A pair of opposite points is marked by dots. It is obvious that in the plane the shortest path is just a segment that connects these two points. Its length is the same as the length of the tetrahedron's edge, i.e. $\boxed{1}$.



See Also

2001 AMC 12 (Problems • Answer Key • Resources (http://www.artofproblemsolving.com/Forum/resources.php?c=182&cid=44&year=2001))	
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Category: Introductory Geometry Problems

2001 AMC 12 Problems/Problem 16

Contents

Problem

A spider has one sock and one shoe for each of its eight legs. In how many different orders can the spider put on its socks and shoes, assuming that, on each leg, the sock must be put on before the shoe?

$\text{(A) }8! \qquad \text{(B) }2^8 \cdot 8! \qquad \text{(C) }(8!)^2 \qquad \text{(D) }\frac {16!}{2^8} \qquad \text{(E) }16!$

Solution

Solution 1

Let the spider try to put on all 16 things in a random order. Each of the $16!$ permutations is equally probable. For any fixed leg, the probability that he will first put on the sock and only then the shoe is clearly $\frac 12$. Then the probability that he will correctly put things on all legs is $\frac 1{2^8}$. Therefore the number of correct permutations must be $\boxed{\frac {16!}{2^8}}$.

Solution 2

Each dressing sequence can be uniquely described by a sequence containing two 1s, two 2s, ..., and two 8s -- the first occurrence of number x means that the spider puts the sock onto leg x, the second occurrence of x means he puts the shoe onto leg x. If the numbers were all unique, the answer would be $16!$. However, since 8 terms appear twice, the answer is $\frac{16!}{(2!)^8} = \boxed{\frac{16!}{2^8}}$.

Solution 3

You can put all 8 socks on first for $8!$ ways and then all 8 shoes on next for $8!$ more ways. This is not the only possibility, so the lower bound is $(8!)^2$. You can choose all 16 in a random fashion, but some combinations would violate the rules, so the upper bound is $16!$. (C) & (E) are the lower and upper bounds, so the answer is in between them, $\boxed{\frac{16!}{2^8}}$.

See Also

2001 AMC 12 Problems/Problem 17

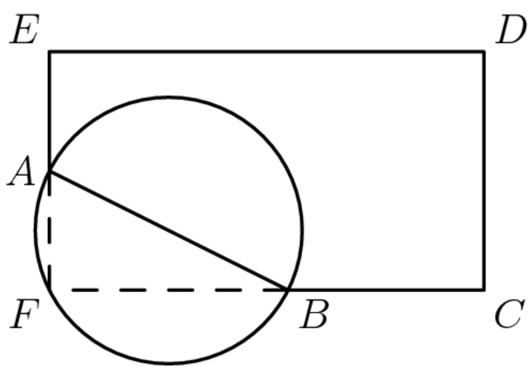
Problem

A point P is selected at random from the interior of the pentagon with vertices $A = (0, 2)$, $B = (4, 0)$, $C = (2\pi + 1, 0)$, $D = (2\pi + 1, 4)$, and $E = (0, 4)$. What is the probability that $\angle APB$ is obtuse?

$\text{(A)}\ \frac{1}{5} \qquad \text{(B)}\ \frac{1}{4} \qquad \text{(C)}\ \frac{5}{16} \qquad \text{(D)}\ \frac{3}{8} \qquad \text{(E)}\ \frac{1}{2}$

Solution

The angle APB is obtuse if and only if P lies inside the circle with diameter AB. (This follows for example from the fact that the inscribed angle is half of the central angle for the same arc.)



The area of AFB is $[AFB] = \frac{AF \cdot FB}{2} = 4$, and the area of $ABCDE$ is $CD \cdot DE - [AFB] = 4 \cdot (2\pi + 1) - 4 = 8\pi$.

From the Pythagorean theorem the length of AB is $\sqrt{2^2 + 4^2} = 2\sqrt{5}$, thus the radius of the circle is $\sqrt{5}$, and the area of the half-circle that is inside $ABCDE$ is $\frac{5\pi}{2}$.

Therefore the probability that APB is obtuse is $\frac{\frac{5\pi}{2}}{8\pi} = \boxed{\text{(C)}\ \frac{5}{16}}$.

See Also

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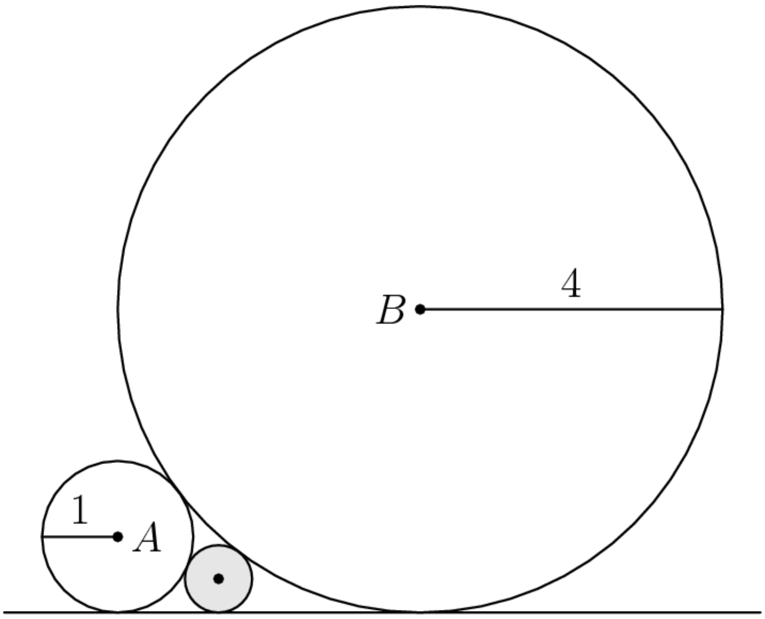
2001 AMC 12 Problems/Problem 18

Contents

Problem

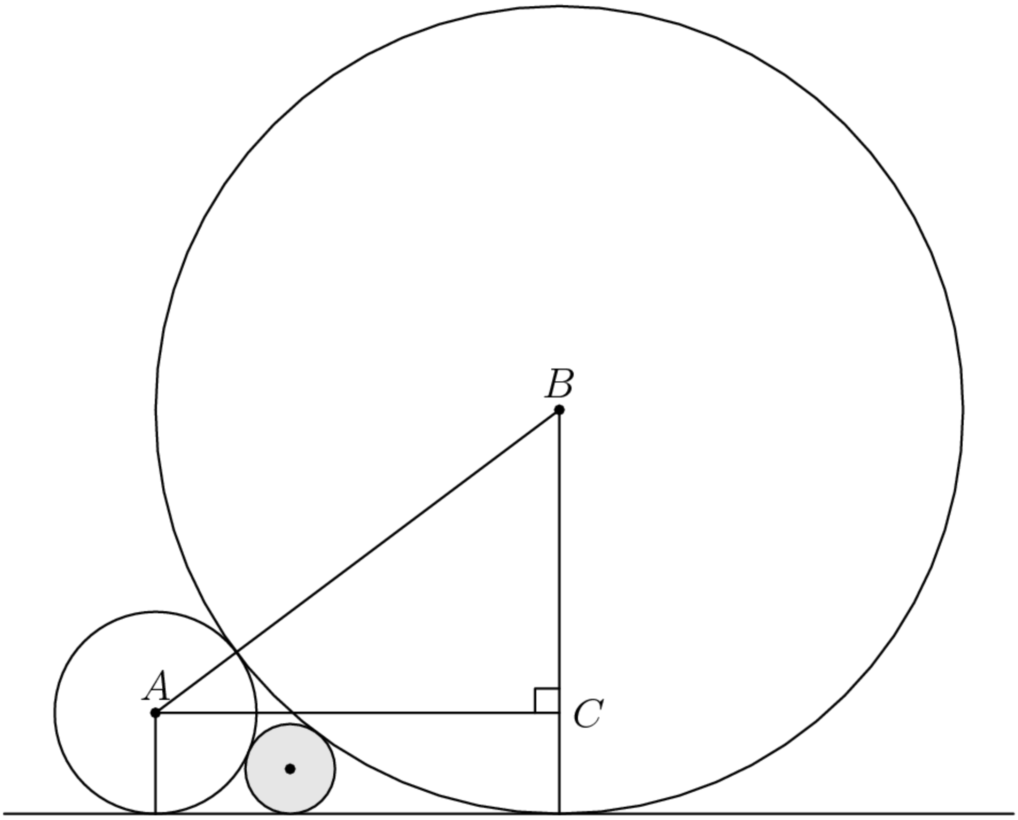
A circle centered at A with a radius of 1 and a circle centered at B with a radius of 4 are externally tangent. A third circle is tangent to the first two and to one of their common external tangents as shown. The radius of the third circle is



$\text{(A) } \frac{1}{3} \qquad \text{(B) } \frac{2}{5} \qquad \text{(C) } \frac{5}{12} \qquad \text{(D) } \frac{4}{9} \qquad \text{(E) } \frac{1}{2}$

Solution

Solution 1



In the triangle ABC we have $AB = 1 + 4 = 5$ and $BC = 4 - 1 = 3$, thus by the Pythagorean theorem we have $AC = 4$.

We can now pick a coordinate system where the common tangent is the x axis and A lies on the y axis. In this coordinate system we have $A = (0, 1)$ and $B = (4, 4)$.

Let r be the radius of the small circle, and let s be the x-coordinate of its center S. We then know that $S = (s, r)$, as the circle is tangent to the x axis. Moreover, the small circle is tangent to both other circles, hence we have $SA = 1 + r$ and $SB = 4 + r$.

We have $SA = \sqrt{s^2 + (1-r)^2}$ and $SB = \sqrt{(4-s)^2 + (4-r)^2}$. Hence we get the following two equations:

$$s^2 + (1-r)^2 = (1+r)^2$$
$$(4-s)^2 + (4-r)^2 = (4+r)^2$$

Simplifying both, we get

$$s^2 = 4r$$
$$(4-s)^2 = 16r$$

As in our case both r and s are positive, we can divide the second one by the first one to get $\left(\frac{4-s}{s}\right)^2 = 4$.

Now there are two possibilities: either $\frac{4-s}{s} = -2$, or $\frac{4-s}{s} = 2$. In the first case clearly $s < 0$, hence this is not the correct case. (Note: This case corresponds to the other circle that is tangent to both given circles and the x axis - a large circle whose center is somewhere to the left of A.) The second case solves to $s = \frac{4}{3}$. We then have $4r = s^2 = \frac{16}{9}$, hence $r = \boxed{\frac{4}{9}}$.

Solution 2

The horizontal line is the equivalent of a circle of curvature 0, thus we can apply Descartes' Circle Formula.

The four circles have curvatures $0, 1, \frac{1}{4}$, and $\frac{1}{r}$.

We have $2\left(0^2 + 1^2 + \frac{1}{4^2} + \frac{1}{r^2}\right) = \left(0 + 1 + \frac{1}{4} + \frac{1}{r}\right)^2$

Simplifying, we get $\frac{34}{16} + \frac{2}{r^2} = \frac{25}{16} + \frac{5}{2r} + \frac{1}{r^2}$

$$\frac{1}{r^2} - \frac{5}{2r} + \frac{9}{16} = 0$$

$$\frac{16}{r^2} - \frac{40}{r} + 9 = 0$$

$$\left(\frac{4}{r} - 9\right)\left(\frac{4}{r} - 1\right) = 0$$

Obviously r cannot equal 4, therefore $r = \boxed{\frac{4}{9}}$.

See Also

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2001 AMC 12 Problems/Problem 19

Problem

The polynomial $p(x) = x^3 + ax^2 + bx + c$ has the property that the average of its zeros, the product of its zeros, and the sum of its coefficients are all equal. The y-intercept of the graph of $y = p(x)$ is 2. What is b?

$\text{(A)}\ -11 \qquad \text{(B)}\ -10 \qquad \text{(C)}\ -9 \qquad \text{(D)}\ 1 \qquad \text{(E)}\ 5$

Solution

We are given $c = 2$. So the product of the roots is $-c = -2$ by Vieta's formulas. These also tell us that $\frac{-a}{3}$ is the average of the zeros, so $\frac{-a}{3} = -2 \implies a = 6$. We are also given that the sum of the coefficients is -2, so $1 + 6 + b + 2 = -2 \implies b = -11$. So the answer is $\boxed{\text{A}}$.

See Also

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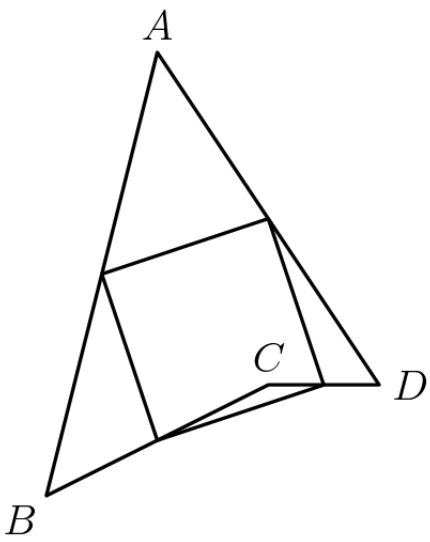
2001 AMC 12 Problems/Problem 20

Problem

Points $A = (3, 9)$, $B = (1, 1)$, $C = (5, 3)$, and $D = (a, b)$ lie in the first quadrant and are the vertices of quadrilateral $ABCD$. The quadrilateral formed by joining the midpoints of $\overline{AB}$, $\overline{BC}$, $\overline{CD}$, and $\overline{DA}$ is a square. What is the sum of the coordinates of point D?

$\text{(A) } 7 \qquad \text{(B) } 9 \qquad \text{(C) } 10 \qquad \text{(D) } 12 \qquad \text{(E) } 16$

Solution



We already know two vertices of the square: $(A + B)/2 = (2, 5)$ and $(B + C)/2 = (3, 2)$.

There are only two possibilities for the other vertices of the square: either they are $(6, 3)$ and $(5, 6)$, or they are $(0, 1)$ and $(-1, 4)$. The second case would give us D outside the first quadrant, hence the first case is the correct one. As $(6, 3)$ is the midpoint of CD, we can compute $D = (7, 3)$, and $7 + 3 = \boxed{10}$.

See Also

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2001 AMC 12 Problems/Problem 21

Problem

Four positive integers a, b, c, and d have a product of $8!$ and satisfy:

$$\begin{aligned} ab + a + b &= 524 \\ bc + b + c &= 146 \\ cd + c + d &= 104 \end{aligned}$$

What is $a - d$?

$\text{(A) }4 \qquad \text{(B) }6 \qquad \text{(C) }8 \qquad \text{(D) }10 \qquad \text{(E) }12$

Solution

Using Simon's Favorite Factoring Trick, we can rewrite the three equations as follows:

$$\begin{aligned} (a+1)(b+1) &= 525 \\ (b+1)(c+1) &= 147 \\ (c+1)(d+1) &= 105 \end{aligned}$$

Let $(e,f,g,h) = (a+1,b+1,c+1,d+1)$. We get:

$$\begin{aligned} ef &= 3\cdot 5\cdot 5\cdot 7 \\ fg &= 3\cdot 7\cdot 7 \\ gh &= 3\cdot 5\cdot 7 \end{aligned}$$

Clearly 7^2 divides fg. On the other hand, 7^2 can not divide f, as it then would divide ef. Similarly, 7^2 can not divide g. Hence 7 divides both f and g. This leaves us with only two cases: $(f,g)=(7,21)$ and $(f,g)=(21,7)$.

The first case solves to $(e,f,g,h)=(75,7,21,5)$, which gives us $(a,b,c,d)=(74,6,20,4)$, but then $abcd\neq 8!$. (We do not need to multiply, it is enough to note e.g. that the left hand side is not divisible by 7.) Also, a - d equals 70 in this case, which is way too large to fit the answer choices.

The second case solves to $(e,f,g,h)=(25,21,7,15)$, which gives us a valid quadruple $(a,b,c,d)=(24,20,6,14)$, and we have $a-d = 24-14 = \boxed{10}$.

See Also

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2001 AMC 12 Problems/Problem 22

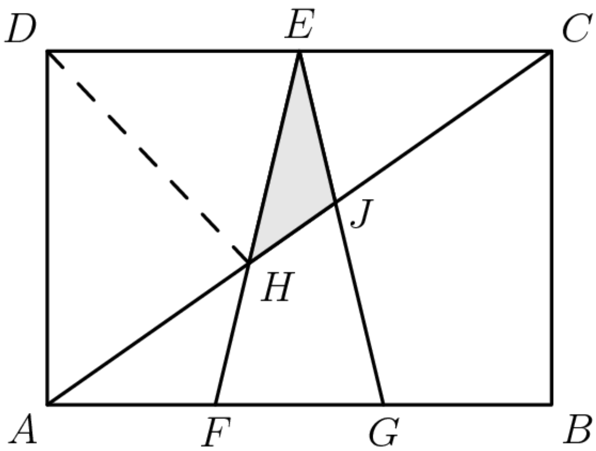
Contents

Problem

In rectangle $ABCD$, points F and G lie on $\overline{AB}$ so that $AF = FG = GB$ and E is the midpoint of $\overline{DC}$. Also, $\overline{AC}$ intersects $\overline{EF}$ at H and $\overline{EG}$ at J. The area of the rectangle $ABCD$ is 70. Find the area of triangle EHJ.

$\text{(A) }\frac{5}{2} \qquad \text{(B) }\frac{35}{12} \qquad \text{(C) }3 \qquad \text{(D) }\frac{7}{2} \qquad \text{(E) }\frac{35}{8}$

Solution



Solution 1

Note that the triangles AFH and CEH are similar, as they have the same angles. Hence $\frac{AH}{HC} = \frac{AF}{EC} = \frac{2}{3}$.

Also, triangles AGJ and CEJ are similar, hence $\frac{AJ}{JC} = \frac{AG}{EC} = \frac{4}{3}$.

We can now compute $[EHJ]$ as $[ACD] - [AHD] - [DEH] - [EJC]$. We have:

- $[ACD] = \frac{[ABCD]}{2} = 35$.
- $[AHD]$ is $2/5$ of $[ACD]$, as these two triangles have the same base AD, and AH is $2/5$ of AC, therefore also the height from H onto AD is $2/5$ of the height from C. Hence $[AHD] = 14$.
- $[HED]$ is $3/10$ of $[ACD]$, as the base ED is $1/2$ of the base CD, and the height from H

is $3/5$ of the height from A. Hence $[HED] = \frac{21}{2}$.

- $[JEC]$ is $3/14$ of $[ACD]$ for similar reasons, hence $[JEC] = \frac{15}{2}$.

Therefore $[EHJ] = [ACD] - [AHD] - [DEH] - [EJC] = 35 - 14 - \frac{21}{2} - \frac{15}{2} = \boxed{3}$.

Solution 2

As in the previous solution, we note the similar triangles and prove that H is in $2/5$ and J in $4/7$ of AC.

We can then compute that $HJ = AC \cdot \left(\frac{4}{7} - \frac{2}{5} \right) = AC \cdot \frac{6}{35}$.

As E is the midpoint of CD, the height from E onto AC is $1/2$ of the height from D onto AC. Therefore we have $[EHJ] = \frac{6}{35} \cdot \frac{1}{2} \cdot [ACD] = \frac{3}{35} \cdot 35 = \boxed{3}$.

See Also

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2001 AMC 12 Problems/Problem 23

Contents

Problem

A polynomial of degree four with leading coefficient 1 and integer coefficients has two zeros, both of which are integers. Which of the following can also be a zero of the polynomial?

$$\text{(A) } \frac{1 + i \sqrt{11}}{2} \qquad \text{(B) } \frac{1 + i}{2} \qquad \text{(C) } \frac{1}{2} + i \qquad \text{(D) } 1 + \frac{i}{2} \qquad \text{(E) } \frac{1 + i \sqrt{13}}{2}$$

Solution

Let the polynomial be P and let the two integer zeros be z_1 and z_2. We can then write $P(x) = (x-z_1)(x-z_2)(x^2+ax+b)$ for some integers a and b.

If a complex number $p+qi$ with $q\neq 0$ is a root of P, it must be the root of x^2+ax+b, and the other root of x^2+ax+b must be $p-qi$.

We can then write $x^2+ax+b = (x-p-qi)(x-p+qi) = (x-p)^2 - (qi)^2 = x^2 - 2px + p^2 + q^2$.

We can now examine each of the five given complex numbers, and find the one for which the values $-2p$ and p^2+q^2 are integers. This is $\boxed{\frac{1 + i \sqrt{11}}{2}}$, for which we have $-2p = -2\cdot\frac 12 = -1$ and $p^2+q^2 = \left(\frac 12 \right)^2 + \left(\frac {\sqrt{11}}2 \right)^2 = \frac 14 + \frac{11}4 = \frac{12}4 = 3$.

(As an example, the polynomial $x^4 - 2x^3 + 4x^2 - 3x$ has zeroes 0, 1, and $\frac{1 \pm i \sqrt{11}}{2}$.)

Solution 2

By Vieta, we know that the product of all four zeros of the polynomial equals the constant at the end of the polynomial. We also know that the two imaginary roots are a conjugate pair (I.E if one is a+bi, the other is a-bi). So the two imaginary roots must multiply to give you an integer. Taking the 5 answers into hand, we find that $\boxed{\frac{1 + i \sqrt{11}}{2}}$ is our only integer giving solution.

See Also

2001 AMC 12 Problems/Problem 24

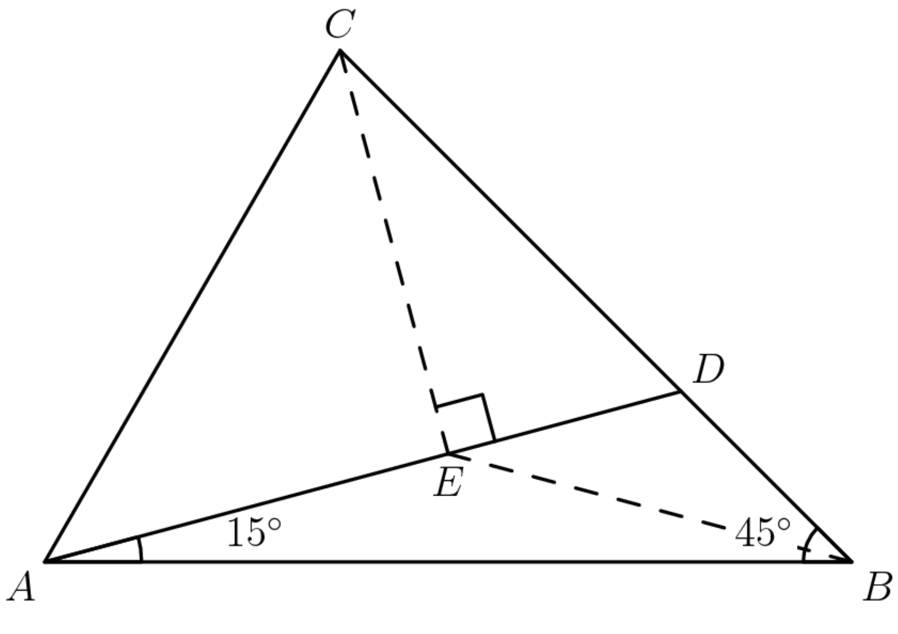
Contents

Problem

In $\triangle ABC$, $\angle ABC = 45^\circ$. Point D is on $\overline{BC}$ so that $2 \cdot BD = CD$ and $\angle DAB = 15^\circ$. Find $\angle ACB$.

$\text{(A) }54^\circ \qquad \text{(B) }60^\circ \qquad \text{(C) }72^\circ \qquad \text{(D) }75^\circ \qquad \text{(E) }90^\circ$

Solution



We start with the observation that $\angle ADB = 180^\circ - 15^\circ - 45^\circ = 120^\circ$, and $\angle ADC = 15^\circ + 45^\circ = 60^\circ$.

We can draw the height CE from C onto AD. In the triangle CED, we have $\frac{ED}{CD} = \cos EDC = \cos 60^\circ = \frac{1}{2}$. Hence $ED = CD/2$.

By the definition of D, we also have $BD = CD/2$, therefore $BD = DE$. This means that the triangle BDE is isosceles, and as $\angle BDE = 120^\circ$, we must have $\angle BED = \angle EBD = 30^\circ$.

Then we compute $\angle ABE = 45^\circ - 30^\circ = 15^\circ$, thus $\angle ABE = \angle BAE$ and the triangle ABE is isosceles as well. Hence $AE = BE$.

Now we can note that $\angle DCE = 180^\circ - 90^\circ - 60^\circ = 30^\circ$, hence also the triangle EBC is isosceles and we have $BE = CE$.

Combining the previous two observations we get that $AE = EC$, and as $\angle AEC = 90^\circ$, this means that $\angle CAE = \angle ACE = 45^\circ$.

Finally, we get $\angle ACB = \angle ACE + \angle ECD = 45^\circ + 30^\circ = \boxed{75^\circ}$.

Trig Bash

WLOG, we can assume that $BD = 1$ and $CD = 2$. As above, we are able to find that $\angle ADB = 60^\circ$ and $\angle ADC = 120^\circ$.

Using Law of Sines on triangle ADB, we find that $\frac{1}{\sin 15^\circ} = \frac{AD}{\sin 45^\circ} = \frac{AB}{\sin 120^\circ}$. Since we know that $\sin 15^\circ = \frac{\sqrt{6}-\sqrt{2}}{4}$, $\sin 45^\circ = \frac{\sqrt{2}}{2}$, and $\sin 120^\circ = \frac{\sqrt{3}}{2}$, we can compute AD to equal $1+\sqrt{3}$ and AB to be $\frac{3\sqrt{2}+\sqrt{6}}{2}$.

Next, we apply Law of Cosines to triangle ADC to see that $AC^2 = (1+\sqrt{3})^2 + 2^2 - (2)(1+\sqrt{3})(2)(\cos 60^\circ)$. Simplifying the RHS, we get $AC^2 = 6$, so $AC = \sqrt{6}$.

Now, we apply Law of Sines to triangle ABC to see that $\frac{\sqrt{6}}{\sin 45^\circ} = \frac{\frac{3\sqrt{2}+\sqrt{6}}{2}}{\sin ACB}$. After rearranging and noting that $\sin 45^\circ = \frac{\sqrt{2}}{2}$, we get $\sin ACB = \frac{\sqrt{6}+3\sqrt{2}}{4\sqrt{3}}$.

Dividing the RHS through by $\sqrt{3}$, we see that $\sin ACB = \frac{\sqrt{6}+\sqrt{2}}{4}$, so $\angle ACB$ is either 75° or 105°. Since 105° is not a choice, we know $\angle ACB = \boxed{75^\circ}$.

Note that we can also confirm that $\angle ACB \neq 105^\circ$ by computing $\angle CAB$ with Law of Sines.

See Also

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2001 AMC 12 Problems/Problem 25

Problem

Consider sequences of positive real numbers of the form $x, 2000, y, \dots$ in which every term after the first is 1 less than the product of its two immediate neighbors. For how many different values of x does the term 2001 appear somewhere in the sequence?

$\text{(A) }1 \qquad \text{(B) }2 \qquad \text{(C) }3 \qquad \text{(D) }4 \qquad \text{(E) more than }4$

Solution

It never hurts to compute a few terms of the sequence in order to get a feel how it looks like. In our case, the definition is that $\forall n>1: ~ a_n = a_{n-1}a_{n+1} - 1$. This can be rewritten as $a_{n+1} = \dfrac{a_n + 1}{a_{n-1}}$.

We have $a_1=x$ and $a_2=2000$, and we compute:

$$\begin{aligned} a_3 & = \frac{a_2+1}{a_1} = \frac{2001}{x} \\ a_4 & = \frac{a_3+1}{a_2} = \frac{\dfrac{2001}{x}+1}{2000} = \frac{2001+x}{2000x} \\ a_5 & = \frac{a_4+1}{a_3} = \frac{\frac{2001+x}{2000x}+1}{\frac{2001}{x}} = \frac{\frac{2001+2001x}{2000x}}{2000\cdot 2001} = \frac{1+x}{2000} \\ a_6 & = \frac{a_5+1}{a_4} = \frac{\frac{1+x}{2000}+1}{\frac{2001+x}{2000x}} = \frac{\frac{2001+x}{2000}}{\frac{2001+x}{2000x}} = x \\ a_7 & = \frac{a_6+1}{a_5} = \frac{x+1}{\frac{1+x}{2000}} = 2000 \end{aligned}$$

At this point we see that the sequence will become periodic: we have $a_6=a_1$, $a_7=a_2$, and each subsequent term is uniquely determined by the previous two.

Hence if 2001 appears, it has to be one of a_1 to a_5. As $a_2=2000$, we only have four possibilities left. Clearly $a_1=2001$ for $x=2001$, and $a_3=2001$ for $x=1$. The equation $a_4=2001$ solves to $x=\dfrac{2001}{2000\cdot 2001 - 1}$, and the equation $a_5=2001$ to $x=2000\cdot 2001 - 1$.

No two values of x we just computed are equal, and therefore there are $\boxed{4}$ different values of x for which the sequence contains the value 2001.

See Also

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