**Directions:**

- Your answers should be in the form specified in the problem. Approximate answers must be at least three decimal places rounded or truncated (ex: $\frac{2}{3} \approx 0.666\ or\ 0.667$), and exact answers must be in simplest form (ex: $\frac{5}{15}$ will not be accepted for $\frac{1}{3}$, and $\sqrt[3]{48}$ will not be accepted for $2\sqrt[3]{6}$). When the desired form is specified in a problem, any other form of the answer will not receive credit.
- You may only use calculators that are permitted on the SAT.
- You may write on this contest and use additional paper you receive from your teacher, but you should write your answers on the **Individual Student Cover Page** to be official and receive credit.
- You will have exactly 45 minutes to complete the problems in this contest. Work quickly and with accuracy.

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**Problems:**

1. Find the exact value of $\frac{2^{2020}-2^{2016}}{2^{2020}+2^{2017}}$. Write your answer in simplest form.

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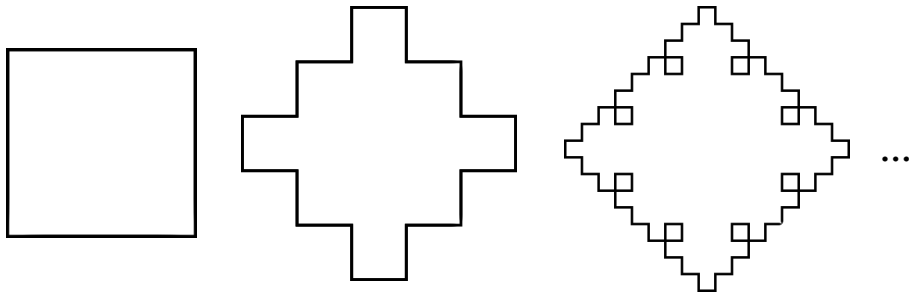
2. In the sequence of shapes shown below, how many sides does the shape in stage 4 have?



stage 0 stage 1 stage 2 ...

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3. $f(x)=\dfrac{1}{1-\dfrac{1}{1-\dfrac{1}{x}}}$. Find $\left|f(2)-f(4)+f(6)\right|$.

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4. Given the points $M(0, 220)$ and $N(n, 2020)$, where $n$ is a positive integer. For how many values of $n$ is the slope of $MN$ an integer?

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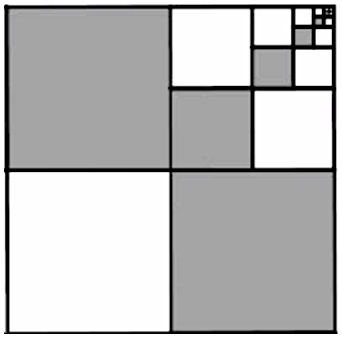
5. If the shading pattern in the top right quarter of the square continues indefinitely, what fraction of the square is shaded?



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6. Let $f(x) = 2 - 3x$ and $g(x) = \dfrac{1}{x+3}$. Find the **exact value** of $g\big(f\big(g(23)\big)\big)$.

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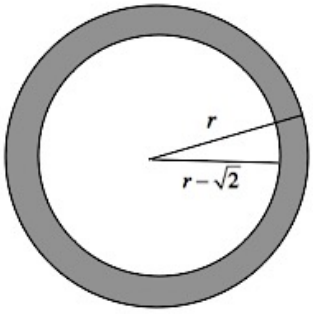
7. The shaded area between two concentric circles with radii $r$ and $r - \sqrt{2}$ is $2\pi + 6\pi\sqrt{2}$ square units.
When the sum of the radii is written as $a + \sqrt{b}$, find $a + b$.

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8. The faces of two fair eight-sided dice are numbered 1 to 8. What is the probability of getting a sum of 8 when you roll the two dice once?

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9. A robot needs to get from (0, 0) to (9, 11) on a gridded level field. The robot needs to avoid a square block that is on the field with its vertices at (2, 2), (6, 2), (2, 6) and (6, 6). If the robot can move freely in any direction on the field, find the shortest distance the robot can travel to reach its destination.

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10. For what value of $m$ do the real solutions of $x^2 - 8x + m = 0$ differ by 5?

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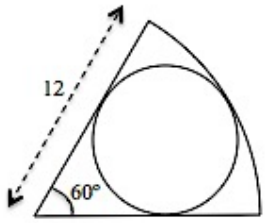
11. A circle is inscribed in a sector of another circle with a radius of 12 units and a central angle of 60º. What is the area of the inscribed circle?

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12. A regular hexagon and a circle have the same area. What is the ratio of the perimeter of the hexagon to the circumference of the circle?

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13. Points $X$ and $Y$ are on a line segment $\overline{WZ}$, with $Y$ between $X$ and $Z$ as shown below.

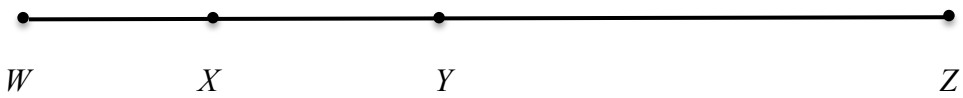


Figure not drawn to scale

If $\frac{WX}{XZ}=\frac{1}{5}$ and $\frac{XY}{YZ}=\frac{2}{3}$, what is the value of $\frac{XY}{WZ}$?

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14. What is the $2020^{\text{th}}$ digit after the decimal in the expansion of $\frac{1}{41}$?

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15. In a certain type of $3\times 3$ array, the entries can be 0 or 1 in such a way that there is no more than one 0 in each row and each column.

For example, the array $\begin{matrix}0&1&1\\1&1&1\\1&1&0\end{matrix}$ is acceptable, whereas $\begin{matrix}0&1&0\\1&1&0\\0&1&1\end{matrix}$ is not acceptable.

How many acceptable $3\times 3$ arrays are possible?

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