1. What is $\sum_{n=3}^{33} 121_n$, where 121_k represents 121 in base k?

2. Find the number of integer solutions to $5n^2 + 2 = m^2$ where $0 \leq n^2 \leq 2020$.

3. Consider the piecewise function $y = F(x)$, which is defined by the following:

$$\begin{cases} \frac{1}{x+1} = \frac{1}{y-1} & \text{if } x \geq 0 \\ \frac{x(y-2)}{y-2} = 1 & \text{if } x < 0. \end{cases}$$

   Find the number of lattice points on $F(x)$ for $-100 \leq x, y \leq 100$.

4. The probability that a randomly selected factor of 2020! is even can be expressed as $\frac{a}{b}$, where a and b are relatively prime. Find $a + b$.

5. Ashwin is biking along the Saratoga Creek Trail one day, as his father walks behind him. He starts at the 0 mile sign. Once Ashwin bikes to the 0.75 mile sign, he turns around and bikes back to his father. After reaching his father, Ashwin bikes to the 0.75 mile sign again, and repeats this process, biking between his father and the 0.75 mile sign. If it takes Ashwin's father 15 minutes to reach the sign, and he meets Ashwin for the 3rd time at 0.65625 miles from his starting point, how fast in miles per hour is Ashwin biking?

6. Simon begins with a hexagon and finds that it has d_1 diagonals. He then creates a new polygon with d_1 sides, and finds that it has d_2 diagonals. He continues in this process, finding that there are d_{n+1} diagonals in the polygon with d_n sides. Find the number of zeroes at the end of d_{100}, when expressed in base 3.

7. Consider an infinitely sided dice, where each side contains a different natural number $[1, \infty)$. The probability of landing on side s is n^s. Find the expected value of the number of the die you land on.

8. Calculate $\sum_{x=0}^{\infty} \binom{4+x}{4} \dot{(} \frac{1}{2})^x$.

9. Darren and Sarah are on a coordinate plane with two circles. Circle D is defined by $x^2 - 4x + y^2 - 4y = 2017$, and Circle S is defined by $x^2 + 4x + y^2 + 4y = 1928$. Darren picks a random point D on Circle D and Sarah picks a random point S on Circle S. If DS is maximized, find the sum of integers a and b such that DS is a root of $x^2 + ax + b$.

10. Let ABC be an equilateral triangle with side length 4. Let X and Y be points on segments AC and AB, respectively, with $AX = 1$ and $AY = 3$. Let P be the intersection of BX and CY, and let line AP intersect the circumcircle of BPC at a point Q, other than P. Then $\frac{BQ}{CQ}$ can be written as $\frac{m}{n}$ for relatively prime positive integers m and n. Find $m + n$.