

# Problem Set 1: Number Theory

Dakahlia Math Club

Week 1

## Problems

1. The first two numbers that are both squares and triangles are 1 and 36. Find the next one and, if possible, the one after that. Can you figure out an efficient way to find triangular-square numbers? Do you think that there are infinitely many?
2. Try adding up the first few odd numbers and see if the numbers you get satisfy some sort of pattern. Once you find the pattern, express it as a formula. Give a geometric verification that your formula is correct.
3. The consecutive odd numbers 3, 5, and 7 are all primes. Are there infinitely many such "prime triplets"? That is, are there infinitely many prime numbers  $p$  such that  $p + 2$  and  $p + 4$  are also primes?
4. It is generally believed that infinitely many primes have the form  $N^2 + 1$ , although no one knows for sure.
  - (a) Do you think that there are infinitely many primes of the form  $N^2 - 1$ ?
  - (b) Do you think that there are infinitely many primes of the form  $N^2 - 2$ ?
  - (c) How about of the form  $N^2 - 3$ ? How about  $N^2 - 4$ ?
  - (d) Which values of  $a$  do you think give infinitely many primes of the form  $N^2 - a$ ?
5. The following two lines indicate another way to derive the formula for the sum of the first  $n$  integers by rearranging the terms in the sum. Fill in the details.

$$\begin{aligned} 1 + 2 + 3 + \cdots + n &= (1 + n) + (2 + (n - 1)) + (3 + (n - 2)) + \cdots \\ &= (1 + n) + (1 + n) + (1 + n) + \cdots \end{aligned}$$

How many copies of  $n + 1$  are in the second line? You may need to consider the cases of odd  $n$  and even  $n$  separately. If that's not clear, first try writing it out explicitly for  $n = 6$  and  $n = 7$ .

# Problems In Elementary Number Theory Problem Solving

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