

### Combinatorics Problems, Part 1

1. Show that  $\binom{r}{r} + \binom{r+1}{r} + \dots + \binom{n}{r} = \binom{n}{r+1}$ .
2. Find a nice formulation for the sum  $\binom{n}{0}^2 + \binom{n}{1}^2 + \dots + \binom{n}{n}^2$ .
3. Let  $S_n = \binom{n}{0} + \binom{n-1}{1} + \dots + \binom{n-2}{\lfloor \frac{n}{2} \rfloor}$ . Show that  $S_n = F_n$ .
4. Given  $S = \{1, 2, \dots, n\}$ , How many unordered pairs  $\{A, B\}$  are there where  $A$  and  $B$  are nonempty subsets of  $S$  with  $A \cap B = \emptyset$ .
5. Do there exist 10,000 10-digit numbers which are all divisible by 7 and are all rearrangements of the same digits.
6. A person has a coat of area 1 composed of five possibly overlapping patches. The area of each patch is at least  $\frac{1}{5}$ . Prove that there are two patches whose overlap has area of at least  $\frac{1}{5}$ .
7. A permutation of  $n$  elements is a one-to-one function  $\pi: \{1, 2, \dots, k\} \rightarrow \{1, 2, \dots, k\}$ . A permutation  $\pi$  of  $\{1, 2, 3, \dots, 2n\}$  has property  $P$  if  $|\pi(i) - \pi(i+1)| = n$  for at least one  $i$ . Show that for any  $n \in \mathbb{Z}$ , there are more permutations with property  $P$  than without it.
8. Let  $M$  be a set of  $n \geq 4$  points in the plane, no three of which are collinear. Initially these points are connected with  $n$  segments so that each point in  $M$  is the endpoint of exactly two segments. Then, we perform moves where we choose two segments  $AB$  and  $CD$  that intersect and replace them by the segments  $AC$  and  $BD$  if none of them is present.

Prove that it is impossible to perform  $\frac{n^2}{4}$  moves.

# Combinatorics Problems And Solutions

**Y Pai**



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