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CALCULATION OF NUMERICAL SEQUENCES AND THEIR SUMS ARISING IN THE PROCESS OF SOLVING SOME PROBLEMS OF COMBINATORICS

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ANNOTATION

Issue 1. How many words can be formed without two o's next to each other by swapping the letters in the word topology?

Solving. The word "topology" is a 10-letter word with 3 letters "o" and the rest of the letters are different. We number the places where the letters in the word topology should be located. For convenience, we replace the number 10 with the number a.

The letters in the word topology are placed in positions 1, 2, 3, 4, 5, 6, 7, 8, 9, a. We express each different option in the form of three-digit numbers in the following way: if the letters o are located in positions 1,2,3, the number 123 is formed, if the letters o are located in positions 5,7,9 if there is, the number 579 is formed. We need to calculate the number of three-digit numbers whose digits are not consecutive numbers that can be formed by the method described above, according to the condition of the problem. First, we count the number of numbers whose first digit is 1.

KEY WORDS: *topology, three-digit numbers, method, case, letters.*

135, 136, 137, 138, 139, 13a

146, 147, 148, 149, 14a

157, 158, 159, 15a

168, 169, 16a

179, 17a

18a

At this point, it is not appropriate to look at the number 531, because it represents the same thing as the number 135. Let's count the number of numbers whose first digit is 2.

246, 247, 248, 249, 24a

257, 258, 259, 25a

268, 269, 26a

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279, 27a

28a

Based on the above, we create the following expression to calculate the number of all non-consecutive numbers.

$$\frac{1+6}{2}*6+\frac{1+5}{2}*5+\frac{1+4}{2}*4+\frac{1+3}{2}*3+\frac{1+2}{2}*2+\frac{1+1}{2}*1=$$

The value of the resulting sum is equal to 56. In each of these 56 options, the remaining 7 letters are 7 in 7 places! Method can be placed. It follows that the number of ways to be searched is 56*7!=282240.

Now we will use the above method to solve a more general problem.

Issue 2. Three letters of a word consisting of n letters are the same, and the remaining letters are different. How many different words can be formed without two identical letters?

Solving. Using the method given in the solution of problem 1, we form the following sum:

$$\frac{1+n-4}{2}*(n-4)+\frac{1+n-5}{2}*(n-5)+\frac{1+n-6}{2}*(n-6)+\cdots+\frac{1+1}{2}*1=$$

$$=\frac{1}{2}((n-4)^2+(n-5)^2+\cdots+1^2+1+2+3+\cdots+n-4)=$$

$$=\frac{(n-2)(n-3)(n-4)}{6}$$

The remaining n-3 different letters in each case (n-3)! Can be placed in the remaining places. From this it follows that the number of words that can be formed by the method described in the condition of the problem is equal to the following:

((n-4)(n-3)(n-2)!)/6

Issue 3. Four letters of a word consisting of n letters are the same, and the rest are different letters. How many words can be formed without two identical letters?

Solving. If we place three of the same letters in 1, 3, 5 places, we cannot place the fourth of the same letters in 6 places. There are n-6 places left to place the fourth letter. Therefore, the number of options we need when one of the same letters is placed first

(1+n-6)/2*(n-6)+(1+n-7)/2*(n-7)+⋯+(1+1)/2*1=((n-4) is equal to (n-5)(n-6))/6.

When one of the same letters is in the second place, one place is lost to place the same letters, i.e. the first place. If we did the above work for n rooms, in this case it is enough to do it for n-1 rooms.

$(1+n-7)/2*(n-7)+(1+n-8)/2*(n-8)+\cdots+(1+1)/2*1=((n-5)\ (n-6)(n-5))/6$

To calculate the number of all possible words, we have the following sum:

$((n-4)(n-5)(n-6))/6+((n-5)(n-6)(n-7))/6+\cdots+(4*3*2)/\ 6+(3*2*1)/6=((n-3)(n-4)(n-5)(n-6))/24$

In each of these cases, put the remaining n-4 different letters in the remaining places (n-4)! Method can be placed. Accordingly, the number of words being searched for

$((n-3)(n-4)(n-5)(n-6))/24*(n-4)!$ Equal to

In problem 2, n cannot be less than 4, and in problem 3, it cannot be less than 7, otherwise there is no possibility of placing the same letters non-adjacent.

Now, the number of words that can be formed in a word with n letters when m letters are the same so that the same letters do not come next to each other

$$((n-m+1)(n-m)(n-m-1)*\ldots*(n-2m+2))/m!$$

we prove that is equal to using the principle of mathematical induction. We saw above that the formula is appropriate in the case where m=3. For the case m=k

$$((n-k+1)(n-k)(n-k-1)*\ldots*(n-2k+2))/k!$$

we consider the formula correct and for the case m=k+1

$$((n-k)(n-k-1)(n-k-2)*\ldots*(n-2k))/((k+1)!)$$

we prove that the formula is correct.

Let's assume that one of the same letters is the first letter of the word to be formed, then we need to place the remaining k letters in n-2 places according to the condition of the problem. This

$((n-2-k+1)(n-2-k)(n-2-k-1)*\ldots*(n-2-2k+2))/k!$

we can do it using the method. If we move the first letter one position to the right, then the remaining k letters

$$((n-3-k+1)(n-3-k)(n-3-k-1)*\ldots*(n-3-2k+2))/k!$$

we can place it in n-3 places using different methods. To find the number of all possible options, we add the following:

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((n-k-1)(n-k-2)(n-k-3)*…*(n-2k))/k!+ ((n-k-2)(n-k-3)(n-k-4)*…*(n -2k-1))/k!+⋯+ +(k*…*3*2*1)/k!=

|(n-k-1)(n-k-2_(n-k-3)*…*(n-2k)=We introduce the designation A.|

=A/k!+A/k!*(n-2k-1)/(n-k-1)+A/k!*(n-2k-1)(n-2k-2)/(n-k-1) (n-k-2) +A/k!*((n-2k-1)(n-2k-2)(n-2k-3)/(n-k-1)(n-k-2)(n-k-3) + ⋯++A/k!*((n-2k-1)(n-2k-3)(n-2k-3)*…*3*2*1)/((n-k-1)(n-k-2)(n-k-3)*…*(k+3)(k+2)(k+1))=

|A/k! take out of the parentheses and write the sum as follows

=A/k!(1+(n-2k-1)/(n-k-1) (1+(n-2k-2)/(n-k-2) (1+(n-2k-3)/(n-k -3) (1+⋯+2/(k+2) (1+1/(k+1))…))))=

=A/k!(1+(n-2k-1)/(n-k-1) (1+(n-2k-2)/(n-k-2) (1+(n-2k-3)/(n-k -3) (1+⋯+3/(k+3)(1+2/(k+2)*(k+2)/(k+1))…))))=

=A/k!(1+(n-2k-1)/(n-k-1) (1+(n-2k-2)/(n-k-2) (1+(n-2k-3)/(n-k -3) (1+⋯+3/(k+3)(1+2/(k+1))…))))=

=A/k!(1+(n-2k-1)/(n-k-1) (1+(n-2k-2)/(n-k-2) (1+(n-2k-3)/(n-k -3) (1+⋯+4/(k+4)(1+3/(k+3)*(k+3)/(k+1))…))))=

=…=A/k! (1+(n-2k-1)/(n-k-1)*(n-k-1)/(k+1))=A/k!*(k+1+n-2k-1)/(k+ 1)=A/k!*(n-k)/(k+1)= ((n-k)(n-k-1)(n-k-2_(n-k-3)*…*(n-2k))/((k+ 1)!)

The claim is proven.

It follows from the solutions above:

2) when the number of the same letters is 5, the number of options in which two identical letters are not adjacent to each other is as follows:

((n-4)(n-5)(n-6)(n-7)(n-8))/5!*(n-5)!

2) we can write the following equations for some sums

(1*2)/2!+(2*3)/2!+⋯+((n-1)*n)/2!=((n+1)*n*(n-1))/3 !=C_(n+1)^3

or 1*2+2*3+⋯+(n-1)*n=1/3 (n+1)*n*(n-1)

(1*2*3)/3!+(2*3*4)/3!+⋯+(n-2)(n-1)n/3!=(n+1)n(n-1) (n-2)/4!=C_(n+1)^4

or 1*2*3+2*3*4+⋯+(n-2)*(n-1)*n=

=1/4 (n+1)*n*(n-1)*(n-2)

(1*2*3*4)/4!+(2*3*4*5)/4!+⋯+(n-3)(n-2)(n-1)n/4!=

=(n+1)n(n-1)(n-2)(n-3)/5!=C_(n+1)^5

or 1*2*3*4+2*3*4*5+⋯+(n-3)*(n-2)*(n-1)*n=

=1/4 (n+1)*n*(n-1)*(n-2)*(n-3)

(1*2*3*4*5)/5!+(2*3*4*5*6)/5!+⋯+((n-4)(n-3)(n-2)(n -1)n)/5!==((n+1)n(n-1)(n-2)(n-3)(n-4))/6!=C_(n+1)^6

or 1*2*3*4*5+2*3*4*5*6+⋯+(n-4)(n-3)(n-2)(n-1)n=

=1/6(n+1)n(n-1)(n-2)(n-3)(n-4)

Such formulas can be written as desired. They are appropriate for natural values of n that satisfy certain conditions. For example, the last formula is valid for n>4.

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