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SOME PROBLEMS OF COMBINATORICS AND THE IMPORTANCE OF EULER-VENN DIAGRAMS IN SOLVING THEM

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Annotation. This article presents some problems of combinatorics - addition and multiplication rules and different methods of solving them, and the advantages of solving using Euler-Venn diagrams in the process of solving are discussed.

Key words: combination, summation rule, finite sets, subsets, elements, tuples, selection, sorting

Introduction. Problems related to finding different combinations of elements and their number are called combinatorics problems. Such problems are studied in combinatorics, a branch of mathematics. Combinatorics mainly emerged as an independent science in the 17th-19th centuries, and scientists such as B. Pascal, P. Ferma, G. Leibniz, Y. Bernoulli, and L. Euler contributed greatly to its development.

Combinatorics mainly studies finite sets, their subsets, tuples made of finite set elements, and problems of finding their number, so it can be considered as a part of set theory.

Sum rule. In combinatorics, the problem of calculating the number of elements of the union of sets is called the sum rule.

I. If $A \cap B = \emptyset$, then

$$n(A \cup B) = n(A) + n(B) \quad (1)$$

will be.

That is, the number of elements of the union of non-intersecting sets A and B is equal to the sum of the number of elements of these sets.

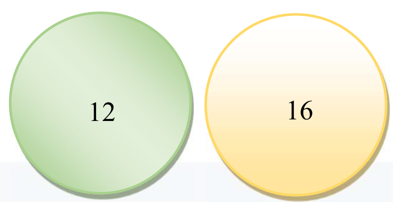
II. If $A \cap B \neq \emptyset$, then

$$n(A \cup B) = n(A) + n(B) - n(A \cap B) \quad (2)$$

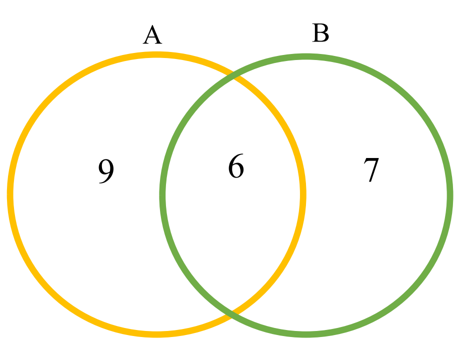
will be. That is, the number of elements of the union of two sets with a common element is equal to the sum of the number of elements of each of the sets minus the number of their common elements. Formula (2) is a general case of formula (1), and formula (1) has $n(A \cap B) \neq \emptyset$, that is, the sets have no common element.

The sum rule for three sets A, B, C with a common element is written as follows:

III. If $A \cap B \cap C \neq \emptyset$, then
$n(A \cup B \cup C) = n(A) + n(B) + n(C) - n(A \cap B) - n(A \cap C) - n(B \cap C) + n(A \cap B \cap C)$ (3)
will be.
The combinatorics problem solved by formula (1) is generally expressed as follows: if element x can be selected in k ways, element y can be selected in m ways, then element "x or y" can be selected in k + m ways.
It is convenient to solve such problems with the help of Euler-Venn diagrams, it is easy to understand, and the answers to all the questions of the problems are much easier to find visually.
(Euler's diagram - (/ˈɔɪlər/) is a diagrammatic means of representing sets and their relationships. Euler's diagram is usually represented by circles. It was invented by Euler. It is used in mathematics, logic, management and other applied fields. The first of "Euler's diagrams" Its first use is usually associated with the Swiss mathematician Leonhard Euler (1707-1783). In the United States, Venn and Euler diagrams were introduced as part of set theory instruction as part of the New Mathematics Movement of the 1960s. Since then, they have been used in other curricula such as reading, as well as accepted by organizations and enterprises.)
For example, if there are 12 apples and 16 pears in the basket, 1 fruit can be selected in 12 + 16 = 28 ways. The solution to this problem is illustrated in Euler-Venn diagrams as follows:

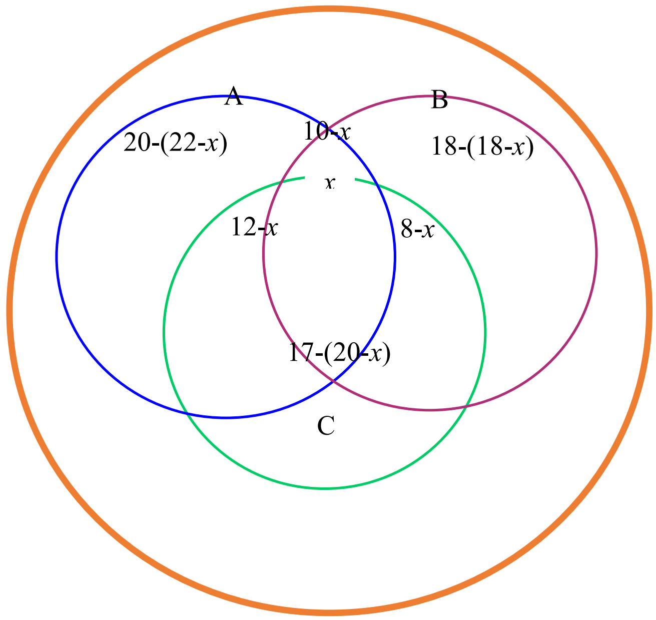


(2) a problem solved by a formula: 45 out of 60 students were able to pass the math exam, 47 were able to pass the Russian language exam. 6 students got "2" in both subjects. How many students are in debt?
Solving. Let A be the set of students who got "2" in mathematics, and B - the set of students who got "2" in Russian language.
$n(A) = 60 — 45 = 15$ $n(A \cap B) = 6$.
$n(B)= 60 — 47 = 13$ $n(A \cup B) = 15 + 13 — 6 = 22$.
Answer: There are 22 outstanding students. Solving this problem is illustrated in Euler-Venn diagrams as follows



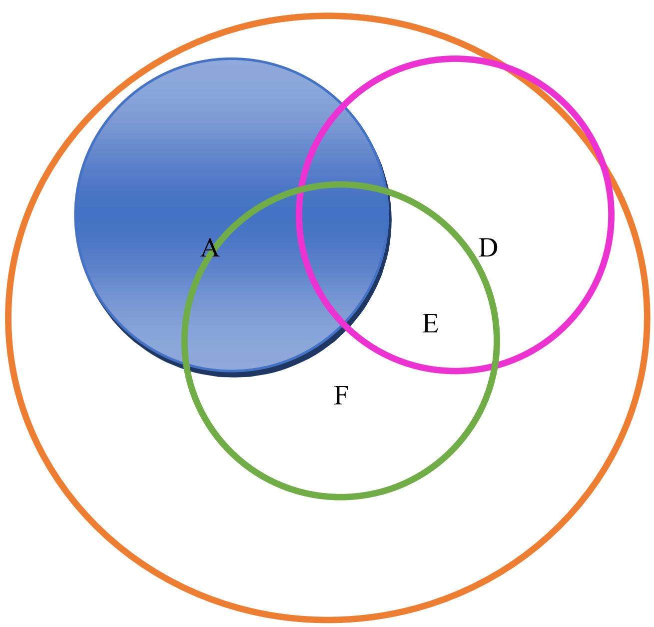
Let's look at the problem solved by formula (3) - summation rule.
Issue 1. There are 30 students in the group. 20 of them are engaged in acrobatics, 18 in

basketball, 17 in swimming, 10 in acrobatics and basketball, 12 in acrobatics and swimming, 8 in swimming and basketball. 1 student is exempt from class. How many students play all kinds of sports? How many students play only 1 sport? How many students play only 2 sports?
Solving. 3 groups are considered in the problem: A - people who practice acrobatics, V - people who practice basketball, C - people who practice swimming. These three sets intersect.
Denoting the number of elements in the intersection of these 3 sets by x, we use the Euler-Venn diagram, which depicts the union of sets A, B, and C as 7 disjoint sets:



Finally, from the Euler-Venn diagram above and the fact that the set of athletic students is the union of the disjoint sets A, D, E, and F, we have the following equation:

20+ 18 — (18 — x) + (8 — x) + 17 — (20 — x) + 1 = 30.
Solving this equation, we find that x = 4.



So, 4 students play all kinds of sports. We find those who play only 1 sport from the following expressions: acrobatics players from the expression 20 — (22 — x) 20 — (22 — 4) = 2, basketball players from the expression 18 — (18 — x) 18 — (18 — 4) = 4, swimmers 17—(20—x) from the expression 17— (20—4) = 1.

We find those who practice only 2 sports from the following expressions: acrobatics and basketball 10 — 4 = 6 from the expression 10 — x, basketball and swimming 8 — 4 = 4 from the expression x, acrobatics and swimmers 12-4 = 8 of the 12-x expression. Now if we count the number of elements of 7 non-intersecting sets, it turns out that the total number of sportsmen is 4+2+4+1+6+4+8 = 29. Let's try to solve this problem directly using formula (3): based on the given n(A∪B∪C)=29, n(A)=20, n(B)=18, Since n(C)=17, n(A∩B) =10, n(A∩C)=12, n(B∩C)=8, n(A∩B∩C)=x

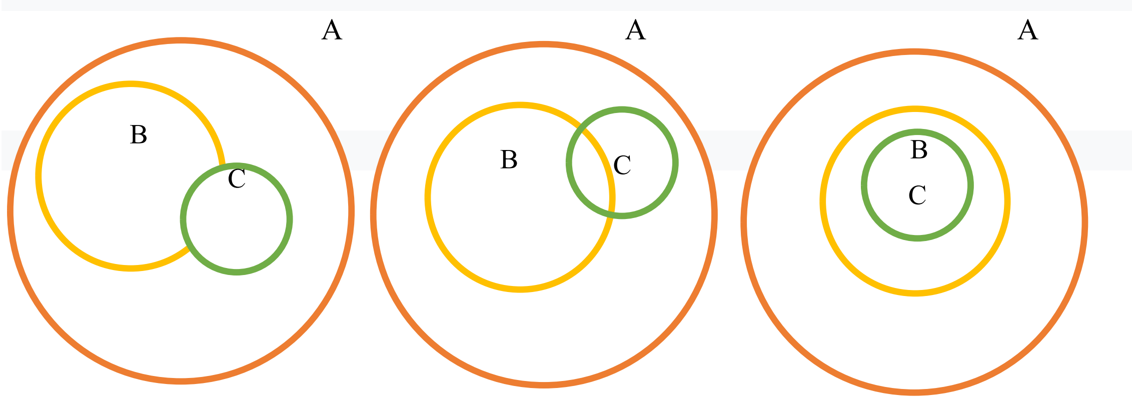
29=20+18+17— 10— 12— 8+x

Solving the equation, we find that x = 4. But when solved by the formula, it is a bit difficult to find the number of people who go to only one sport, and those who go to two sports. Therefore, Euler-Venn diagrams are very important in solving such problems.

Issue 2. Out of 60 students, 25 study German and 15 study English. What is the number of students who know both languages and who know at least 1 language?

Solving. 3 sets are considered in the problem: A is a set of all students, B is a set of students learning German, C is a set of students learning English. According to the condition of the problem, n(A) = 60, n(B) = 25, n(S) = 15.

The relationship between sets A, B, and C can be depicted in Euler-Venn diagrams as follows. The number of bilingual students is related to finding the number of elements of the intersection of sets B and C. The number of students who know at least 1 language is related to finding the number of elements of the union of two sets.



n(B∩C)= 0
n(B∪C)=40

n(B∩C)= 15
n(B∪C)=25

If x is the number of bilingual students, 0 ≤ x ≤ 15 (x ∈ N_o) u is the number of students who know at least 1 language, 25 ≤ u ≤ 40 (u∈N).

Multiplication rule. The rule that allows you to find the number of elements of the Cartesian product of finite sets is called the product rule.

Let's see how many ordered (ai, bj.) pairs can be made from the elements of the sets A = {a1, a2, …, an} and B = {b1,b2, …, bm}. We arrange all pairs in order as follows:

(a1; b1), (a1; b2), … , (a1; bm),(a2; b1), (a2; b2), … , (a2; bm),(an; b1), (an; b2), … , (an; bm).
This table has n rows and m columns, and the number of all pairs in it is n·m. Here n = n(A) and m = n(B).
The multiplication rule is written in the form n(A×B) = n(A) · n(B).
General view of the problem of combinatorics related to the rule of multiplication: "If element x can be selected in m ways, element y can be selected in n ways, then the ordered pair (x;y) can be selected in mn ways."
For more than two sets, this formula is written as follows:
n(A1×A2× … ×An) = n(A1) ·n(A2) ·… · n(An),(n>2).
For example, if it is possible to go from city A to city B in 3 ways, and from city B to city C in two ways, how many different ways can you go from city A to city C?
If the 1st part of the road can be covered in 3 different ways, the 2nd part can be covered in 2 different ways, then the general road can be covered in 3·2 = 6 ways.
Generalized multiplication rule: "If element x can be selected by m methods, and element y can be selected by n methods after selecting x, then the pair (x;y) can be selected by mn methods."
Matter. How many different two-digit numbers are there?
Solving. Number 1 can be selected in 9 ways (1, 2, ..., 9), and number 2 can be selected in 9 ways (numbers other than decimals starting from zero). There are 9·9 = 81 such numbers in total.
Suggesting the following combinatorics problems to students also encourages them to think logically:
1) There are 4 pomegranates, 5 pears and 6 apples in the basket. How many ways can you choose one fruit from the basket?
A) 15 B) 120 C) 74 D) 10
2) There are 4 pomegranates, 5 pears and 6 apples in the basket. In how many ways can you choose two fruits with different names from the basket?
A) 15 B) 120 C) 74 D) 10
3) There are 4 pomegranates, 5 pears and 6 apples in the basket. In how many ways is it possible to choose one pomegranate, pear and apple from the basket?
A) 15 B) 120 C) 74 D) 10

Conclusions: The following conclusions can be drawn from the above points: In teaching some simple problems of combinatorics - addition and multiplication rules and different methods of solving them, if we explain to students the advantages of solving using Euler-Venn diagrams in the process of solving, students will be able to use them. , skills, qualifications are formed. Considering that Euler-Venn diagrams are currently used in various fields of education and production, it shows that there will be a need to use Euler-Venn diagrams in the further activities of students. So, this topic is one of the actual topics.

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