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SOLVING PROBLEMS OF APPLICATIONS OF COLLECTION THEORY

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Annotation
In secondary schools, mathematics is studied on the basis of set theory. The article shows the importance of using the formulas of predicate algebra and set theory in solving mathematical problems. The issues raised here can be used not only to strengthen students' knowledge on the topic of collections, but also to organize math circle classes.

Keywords: Set, predicate, operations on sets, equally strong formulas, number of set elements, problems.

In-depth study of mathematical science is important to know in detail the laws of mathematical logic and the elements of set theory. Therefore, in mathematics lessons, students need to be taught more deeply the science of mathematical logic and the laws of set theory, especially the properties of operations on sets, the proofs of these properties and their application to problem solving.

Although operations on collections have many properties, some of these properties have been studied in school mathematics textbooks. With this in mind, we consider in detail the properties of operations on sets, the proofs of these properties, and their application to problem solving.

We denote the sets by the capital letters A, B, S, ... of the Latin alphabet and the number of elements of the finite set A by n (A).

We mention the descriptions of the actions on the sets.

Definition 1. A set consisting of all the elements belonging to set A or set B is called a combination of sets A and B (denoted as AUV).

Definition 2. A set consisting of all the elements belonging to sets A and B is called the intersection of sets A and B (denoted as $A \cap V$).

Definition 3. A set consisting of all elements belonging to set A and not belonging to set B is called the difference of sets A and B (denoted as $A \setminus V$).

Definition 4. If each element belonging to set A belongs to set V and each element belonging to set V belongs to set A, then sets A and B are called equal sets (defined as A = V).

Definition 5. If each element of set V belongs to set A, set V is called a part set of set A (denoted as $V \subset A$-).

1- property. $A = B \rightarrow n(A) = n(B)$ (1)

2- property. $A \cap B = \varnothing \rightarrow n(AUB) = n(A) + n(B)$ (2)

3- property. $B \subset A \rightarrow n(A \setminus B) = n(A) - n(B)$ (3)

4- property. $A \setminus V = A \setminus A \cap V$ (4)

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Proof of properties 1-4 follows directly from definitions 1-5.
5- property. For optional A and B kits
n (A \ B) = n (A) -n (A∩B) (5)
n (AUB) = n (A) + n (B) -n (A∩B) (6)
equations are reasonable.
Proof. Using equations (3) and (4) and the relation A∩V⊂A, we construct the equation n (A \ B) = n (A \ A∩B) = n (A) -n (A∩B) (5). To prove equation (6), we write AUV in the form of a combination of non-intersecting sets AUV = (A \ V) U (A∩V) U (V \ A) and use equations (2), (3) and (5).
n (AUB) = n ((A \ B) U (A∩B) U (B \ A)) = n (A \ B) + n (A∩B) + n (B \ A) =
= n (A) -n (A∩B) + n (A∩B) + n (B) -n (B∩A) = n (A) + n (B) -n (A∩B)
Thus equation (6) is also valid.
6-property. For arbitrary sets A, B, C (AUV) ∩S = A∩SUV∩S (7) equals.
Proof. Let x (AUV) ∩S. From this
(x AUV) ∧ (x S) → (x A x V) ∧ (x S) → (x A) ∧ (x C) (x B) ∧ (x C) →
→ (x A∩C) (x B∩C) → x A∩CUB∩C.
We now show that the arbitrary x element corresponding to the right side of equation (7) belongs to its left side.
Let x be A∩CUB∩C. From this
(x A∩C) (x B∩C) → (x A) ∧ (x C) (x B) ∧ (x C) → (x A x V) (x S) →
→ (x (x S) → x (AUV) ∩S.
Thus equation (7) is correct.
7 properties. For optional A, B, C sets
n (AUBUC) = n (A) + n (B) + n (C) -n (A∩B) -n (A∩C) -n (B∩C) + n (A∩B ∩C) Equation (8) is valid.
Proof. We use equations (6) - and (7).
n (AUBUC) = n ((AUB) UC) = n (AUB) + n (C) -n ((AUB) ∩C) =
= n (A) + n (B) -n (A∩B) + n (C) -n (A∩CUB∩C) =
= n (A) + n (B) + n (C) -n (A∩B) - (n (A∩C) + n (B∩C) -n (A∩C∩B∩C)) =
= n (A) + n (B) + n (C) -n (A∩B) -n (A∩C) -n (B∩C) + n (A∩B∩C).
Hence, equation (8) is correct.
Such equations can be derived even when the number of participants is 4, 5, and so on, n. For example, to calculate n (AUBUCUD) when the number of participants is 4, we can use the equations (6), (7) and (8) to derive the following formula.
n (AUBUCUD) = n (A) + n (B) + n (C) + n (D) - n (A∩B) -n (A∩C) -
-n (A∩D) -n (B∩C) -n (B∩D) -n (C∩D) + n (A∩B∩C) + n (A∩B∩D) +
+ n (A∩C∩D) + n (B∩C∩D) -n (A∩B∩C∩D) (9)
The following properties of the operations on the sets are also proved as above.
8-property. AU (V∩S) = (AUV) ∩ (AUS)
9-property. A \ (VUS) = (A \ V) ∩ (A \ S)

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10 properties. $A \setminus (V \cap S) = A \setminus A \cap B \cap S$
11th property. $A \setminus (V \cap S) = (A \setminus V) \cup (A \setminus S)$
12-property. $A \cap (V \setminus S) = (A \cap V) \setminus S$
Property 13.
14- property. $A \cup V \setminus S = (A \setminus S) \cup (V \setminus S)$
15th property. $(A \setminus S) \cap (V \setminus S) = A \cap V \setminus A \cap V \cap S$.
We consider the application of the properties discussed above.
Issue 1. = - Write the set of all numbers divisible by 2 and 3 that belong to the set.
Solution: $\{a \in U \mid a \vdots 2 \wedge 3\} = \{a \in U \mid a = 6k, k = 1,4\} = \{6,12,18,24\}$
Answer: $\{6,12,18,24\}$.
Issue 2. $=\{1,2,3, \dots, 25\}$ - Write a set of all numbers that are not divisible by 2 and 3 belonging to the set.
Solution: We solve this problem in 2 different ways.
Method 1 $\{a \in U \mid \overline{a \vdots 2 \wedge 3}\} = \{a \in U \mid \overline{a \vdots 2} \vee \overline{a \vdots 3}\} =$
$= \{a \in U \mid \overline{a \vdots 2}\} \cup \{a \in U \mid \overline{a \vdots 3}\} = \{1,3,5,7,9,11,13,15,17,19,21,23,25\} \cup$
$\cup \{1,2,4,5,7,8,10,11,13,14,16,17,19,20,22,23,25\} =$
$= \{1,2,3,4,5,7,8,9,10,11,13,14,15,16,17,19,20,21,22,23,25\}$.
Method 2. $\{a \in U \mid \overline{a \vdots 2 \wedge 3}\} = U \setminus \{a \in U \mid a \vdots 2 \text{ ва } 3\} = U \setminus \{6,12,18,24\} =$
$= \{1,2,3,4,5,7,8,9,10,11,13,14,15,16,17,19,20,21,22,23,25\}$.
Answer: $\{1,2,3,4,5,7,8,9,10,11,13,14,15,16,17,19,20,21,22,23,25\}$.
In solving such problems, the principle of transition from simple to complex should be followed. If students are given Problem 2 without being taught to solve Problem 1, they may misunderstand the meaning of the phrase “numbers that are not divisible by 2 and 3” as “numbers that are not divisible by 2 and numbers that are not divisible by 3”. As a result, the issue is as follows:
$\{a \in U \mid \overline{a \vdots 2 \wedge 3}\} = \{a \in U \mid \overline{a \vdots 2} \wedge \overline{a \vdots 3}\} =$
$= \{a \in U \mid \overline{a \vdots 2}\} \cap \{a \in U \mid \overline{a \vdots 3}\} = \{1,3,5,7,9,11,13,15,17,19,21,23,25\} \cap$
$\cap \{1,2,4,5,7,8,10,11,13,14,16,17,19,20,22,23,25\} =$
$= \{1,5,7,11,13,17,19,23,25\}$ may solve incorrectly.
Students who have fully learned how to solve the above problems correctly can also solve the following problems correctly without difficulty.
Issue 3. $U = \{1,2,3, \dots, 100\}$- how many numbers belong to the set and are not divisible by 3 and 4.
Solution: This is divisible by 3 and 4 from the set $\{3 \cdot 4 \cdot k \mid k = \overline{1,8}\} =$
$= \{12,24,36,48,60,72,84,96\}$ if we subtract the 8 numbers in the set, the remaining 92 numbers in the set are not divisible by 3 and 4.
Answer: 92.
Issue 4. $U = \{1,2,3, \dots, 100\}$- how many elements of the set are divisible by 2 and not by 3.
Solution: To solve this problem, we use the following definitions:
$A = \{2k \mid k = \overline{1,50}\}, B = \{3k \mid k = \overline{1,33}\}$ based on these definitions, problem 4 comes to calculate the number of elements of the set $A \setminus B$. We use equation (5).

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n (A \ B) = n (A) -n (A∩B) = 50-16 = 34.
Answer: 34.
In ancient times, the following issues were used to obtain information about pirates.
Issue 5. In a battle with 100 robbers, 70 robbers were wounded in the eye, 75 in the robber's arm, 80 in the robber's hand and 85 in the robber's leg.
a) at least several robbers were wounded in the eye and ear;
b) at least a few robbers were injured in the eye, ear and hand.
c) There may be at least a number of robbers wounded in the eye, ear, arm and leg.
Solution: To solve this problem, we define a set of pirates with an letter A in the eye, a set of pirates with an ear wound in the letter V, a set of pirates in the arm with the letter C, and a set of pirates in the leg with a letter D. In that case
$n(A \cap B)$, $n(A \cap B \cap C)$, $n(A \cap B \cap C \cap D)$ comes to determine which numbers cannot be smaller than.
To determine this, (6) follows from equations (8) (9) and the case condition

$$n(A \cup B) \leq 100 \quad (14)$$

$$n(A \cup B \cup C \cup D) \leq 100 \quad (15)$$

$$n(A \cap B \cup C) \leq 100 \quad (16)$$

$$n(A \cap B \cap C \cup D) \leq 100 \quad (17)$$

we use inequalities:
a) (6), (14) $\Rightarrow$ $n(A \cap B) = n(A) + n(B) - n(A \cup B) \geq 70 + 75 - 100 = 45.$ $n(A \cap B) \geq 45$ (18)
This means that there are at least 45 robbers with eye and ear injuries.
b) (6), (16) $\Rightarrow n(A \cap B \cap C) = n(A \cap B) + n(C) - n(A \cap B \cup C) \geq$
$\geq 45 + 80 - 100 = 25.$

$$n(A \cap B \cap C) \geq 25 \quad (19)$$

That means at least 25 robbers were injured in the eye, ear and arm.
c) (6), (17) ва (19) $\Rightarrow n(A \cap B \cap C \cap D) = n(A \cap B \cap C) + n(D) -$
$-n(A \cap B \cap C \cup D) \geq 25 + 85 - 100 = 10.$

$$n(A \cap B \cap C \cap D) \geq 10 \quad (20)$$

This means that at least 10 robbers were injured in the eye, ear, hand and leg.
Students who have thoroughly studied the issues discussed above and how to solve them can also solve the following problems correctly without difficulty.
Issue 6. U={1,2,3, …. , 100}- What are the numbers in the set that are divisible by 2 and not divisible by 3 and 5?
Issue 7. U={1,2,3, …. , 100}- What are the non-multiple numbers 2, 3, 5, and 11 in the set?
Issue 8. U={1,2,3, …. , 100}- What are the indivisible numbers 2, 3, and 5 in the set?
Issue 9.U={1,2,3, …. , 100}- What are the indivisible numbers 2, 3, 5, and 11 that belong to the set?
Issue 10. Of the 100 students who participate in the school's math or computer science circles, 75 participate in the math circle and 65 in the computer science circle. How many of these students attend both clubs.

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Issue 11. Of the 100 members of the circle, 80 participate in the math circle and 70 in the computer circle. How many students are in the math circle only?
Issue 12. Of the 200 entrepreneurs, 140 are engaged in poultry farming and 150 in fishing. At least a few entrepreneurs are involved in poultry and fishing.
Issue 13. Of the 200 entrepreneurs, 140 are engaged in the production of shoes, 150 in the production of shirts and 160 in the production of pants. At least a few entrepreneurs are engaged in the production of three types of products (shoes, shirts and pants).
Issue 14. Of the 200 entrepreneurs, 140 are engaged in the production of shoes, 150 in the production of shirts, 160 in the production of pants and 170 in the production of suits. At least a few entrepreneurs are engaged in the production of four types of products (shoes, shirts, pants and suits).
We can write each of the problems discussed above in a parametric form and construct many problems for the application of set theory by substituting the parameters with arbitrary natural numbers. These issues can be used to teach students the theory of sets and its applications, to conduct circle classes in mathematics, and most importantly, to develop students' problem-solving and creative thinking skills.

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