

# Operations on sets

# Things you need to learn:

The following operations on sets:

- Union of two sets:  $A \cup B$ ;
- Intersection of two sets:  $A \cap B$ ;
- Difference of two sets:  $A - B$ ;
- Complement of a given set:  $A'$ .

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Note that the **union** is sometimes also called the **sum** and the **intersection** is sometimes called the **product**.

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- If  $A \subseteq B$  and  $B \subseteq C$ , then  $A \subseteq C$ .

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You may find this analogous to  $\leq$  and  $<$  operators.

# Union

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- $\emptyset \cup A = A$ ;



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In particular:

- $\emptyset \cup A = A$ ;
- $\emptyset \cap A = \emptyset$ ;

# Difference

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If  $A = \{1, 2, 3\}$  and  $B = \{2, 3, 4\}$ , then  $A - B = \{1\}$ , but  $B - A = \{4\}$

# Example 1

Let  $A = \{1, 2, 3, 4, 5, 6, 7\}$  and  $B = \{2, 4, 6, 8, 10\}$ .  
Find  $A \cup B$ ,  $A \cap B$ ,  $A - B$  and  $B - A$ .

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$A \cup B$  denotes all elements that are in at least one of  $A$  or  $B$ , so we have:

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Note:  $1 \notin A \cap B$ , since 1 does not belong to  $B$ . Similarly  $8 \notin A \cap B$ , since 8 does not belong to  $A$ .

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$$A - B = \{1, 3, 5, 7\}$$

Note:  $2 \notin A - B$ , since 2 belongs to  $B$ , so we excluded it. Also  $9 \notin A - B$ , since 9 wasn't in  $A$  in the first place.

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$B - A$  is difference between  $B$  and  $A$ , it's the set of all elements in  $B$  that are not in  $A$ . We have:

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$$B - A = \{8, 10\}$$

Note:  $6 \notin B - A$ , since 6 is in  $A$ , so we excluded it. And  $9 \notin B - A$ , since 9 wasn't in  $B$ .

# Complement

Usually in a given problem we have a set  $U$  - the universal set, which denotes all elements that are considered for the given problem. Note that we have:  $A \subseteq U$  for any set  $A$ .

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# Complement

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We can then define the complement of a set  $A$ , denoted  $A'$ , as all elements that are not in  $A$ .

Note that  $A' = U - A$ .

## Example 2

Let  $U$  be the set of positive integers less than 10 and  $A = \{2, 3, 5, 7\}$  and  $B = \{2, 4, 6, 8\}$ .

Find  $A'$ ,  $B'$ ,  $A' \cap B'$ .

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$$A' = \{1, 4, 6, 8, 9\}$$

Note:  $2 \notin A'$ , since 2 is an element of  $A$  and in  $A'$  we want elements that are not in  $A$ . On the other hand  $12 \notin A'$ , since 12 does not belong to our universal set, so we don't even consider it.

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Note:  $2 \notin B'$ , since 2 is in  $B$  and  $12 \notin B'$ , since 12 does not belong to the universal set.

## Zadanie 2

$A' \cap B'$  is the intersection of  $A'$  and  $B'$ . We know that:

$$A' = \{1, 4, 6, 8, 9\}$$

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So the intersection of the above sets is:

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Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4\}$ ,  $B = \{3, 6, 9\}$  and  $C = \{6, 7, 8, 9\}$ .



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$$(B \cup C) \cap A = \{3\};$$

$$(A \cup C)' = \{5, 10\}$$

$$(A \cap B)' = \{1, 2, 4, 5, 6, 7, 8, 9, 10\};$$

$$(A \cup B) \cap C = \{6, 9\};$$

$$(A' \cap B') \cup C'$$

## Exercise 1 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4\}$ ,  $B = \{3, 6, 9\}$  and  $C = \{6, 7, 8, 9\}$ .

Find:

$$A' \cap B' = \{5, 7, 8, 10\};$$

$$(B \cup C) \cap A = \{3\};$$

$$(A \cup C)' = \{5, 10\}$$

$$(A \cap B)' = \{1, 2, 4, 5, 6, 7, 8, 9, 10\};$$

$$(A \cup B) \cap C = \{6, 9\};$$

$$(A' \cap B') \cup C' = \{1, 2, 3, 4, 5, 7, 8, 10\}$$

## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$A \cup B$$

## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$A \cup B = \{1, 2, 3, 4, 5, 6, 7, 8, 10\};$$

## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$A \cup B = \{1, 2, 3, 4, 5, 6, 7, 8, 10\};$$

$$A - C$$



## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$A \cup B = \{1, 2, 3, 4, 5, 6, 7, 8, 10\};$$

$$A - C = \{1, 4, 6\};$$

## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$A \cup B = \{1, 2, 3, 4, 5, 6, 7, 8, 10\};$$

$$A - C = \{1, 4, 6\};$$

$$B - C$$

## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$A \cup B = \{1, 2, 3, 4, 5, 6, 7, 8, 10\};$$

$$A - C = \{1, 4, 6\};$$

$$B - C = \{4, 6, 8, 10\}$$

## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$A \cup B = \{1, 2, 3, 4, 5, 6, 7, 8, 10\};$$

$$A - C = \{1, 4, 6\};$$

$$B - C = \{4, 6, 8, 10\}$$

$$A'$$

## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$A \cup B = \{1, 2, 3, 4, 5, 6, 7, 8, 10\};$$

$$A - C = \{1, 4, 6\};$$

$$B - C = \{4, 6, 8, 10\}$$

$$A' = \{8, 9, 10\};$$

## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$A \cup B = \{1, 2, 3, 4, 5, 6, 7, 8, 10\};$$

$$A - C = \{1, 4, 6\};$$

$$B - C = \{4, 6, 8, 10\}$$

$$A' = \{8, 9, 10\};$$

$$C'$$

## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$A \cup B = \{1, 2, 3, 4, 5, 6, 7, 8, 10\};$$

$$A - C = \{1, 4, 6\};$$

$$B - C = \{4, 6, 8, 10\}$$

$$A' = \{8, 9, 10\};$$

$$C' = \{1, 4, 6, 8, 9, 10\};$$

## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$A \cup B = \{1, 2, 3, 4, 5, 6, 7, 8, 10\};$$

$$A - C = \{1, 4, 6\};$$

$$B - C = \{4, 6, 8, 10\}$$

$$A' = \{8, 9, 10\};$$

$$C' = \{1, 4, 6, 8, 9, 10\};$$

$$A' \cup C'$$



## Exercise 2

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$A \cup B = \{1, 2, 3, 4, 5, 6, 7, 8, 10\};$$

$$A - C = \{1, 4, 6\};$$

$$B - C = \{4, 6, 8, 10\}$$

$$A' = \{8, 9, 10\};$$

$$C' = \{1, 4, 6, 8, 9, 10\};$$

$$A' \cup C' = \{1, 4, 6, 8, 9, 10\}$$

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$(A \cap B)'$$

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$(A \cap B)' = \{1, 3, 5, 7, 8, 9, 10\};$$

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$(A \cap B)' = \{1, 3, 5, 7, 8, 9, 10\};$$

$$A' \cap (B \cup C)$$

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$(A \cap B)' = \{1, 3, 5, 7, 8, 9, 10\};$$

$$A' \cap (B \cup C) = \{8, 10\};$$

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$(A \cap B)' = \{1, 3, 5, 7, 8, 9, 10\};$$

$$A' \cap (B \cup C) = \{8, 10\};$$

$$(B \cap C) - A$$



## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$(A \cap B)' = \{1, 3, 5, 7, 8, 9, 10\};$$

$$A' \cap (B \cup C) = \{8, 10\};$$

$$(B \cap C) - A = \emptyset$$

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$(A \cap B)' = \{1, 3, 5, 7, 8, 9, 10\};$$

$$A' \cap (B \cup C) = \{8, 10\};$$

$$(B \cap C) - A = \emptyset$$

$$A - (B \cup C)$$

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$(A \cap B)' = \{1, 3, 5, 7, 8, 9, 10\};$$

$$A' \cap (B \cup C) = \{8, 10\};$$

$$(B \cap C) - A = \emptyset$$

$$A - (B \cup C) = \{1\};$$

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$(A \cap B)' = \{1, 3, 5, 7, 8, 9, 10\};$$

$$A' \cap (B \cup C) = \{8, 10\};$$

$$(B \cap C) - A = \emptyset$$

$$A - (B \cup C) = \{1\};$$

$$C' - B'$$

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$(A \cap B)' = \{1, 3, 5, 7, 8, 9, 10\};$$

$$A' \cap (B \cup C) = \{8, 10\};$$

$$(B \cap C) - A = \emptyset$$

$$A - (B \cup C) = \{1\};$$

$$C' - B' = \{4, 6, 8, 10\};$$

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$(A \cap B)' = \{1, 3, 5, 7, 8, 9, 10\};$$

$$A' \cap (B \cup C) = \{8, 10\};$$

$$(B \cap C) - A = \emptyset$$

$$A - (B \cup C) = \{1\};$$

$$C' - B' = \{4, 6, 8, 10\};$$

$$(A' \cup B) - C$$

## Exercise 2 ctd.

Let  $U = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ ,  $A = \{1, 2, 3, 4, 5, 6, 7\}$ ,  
 $B = \{2, 4, 6, 8, 10\}$  and  $C = \{2, 3, 5, 7\}$ .

Find:

$$(A \cap B)' = \{1, 3, 5, 7, 8, 9, 10\};$$

$$A' \cap (B \cup C) = \{8, 10\};$$

$$(B \cap C) - A = \emptyset$$

$$A - (B \cup C) = \{1\};$$

$$C' - B' = \{4, 6, 8, 10\};$$

$$(A' \cup B) - C = \{4, 6, 8, 9, 10\}$$

The short test will be similar to the exercises above.



In case of any questions you can email me at [T.J.Lechowski@gmail.com](mailto:T.J.Lechowski@gmail.com).