

Algebra.

Sets.

- I put a skirt, a book, a toothbrush, a coffee mug, and an apple into a bag. Can we call this collection of items a set? Do all these objects have something in common?

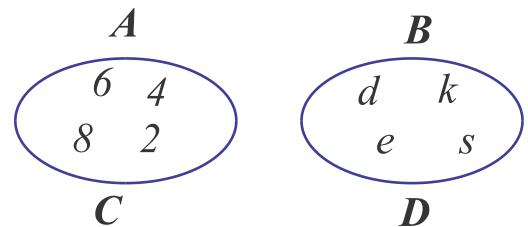
A set is a collection of objects that have something in common.



There are two ways of describing, or specifying, the members of a set. One way is by listing each member of the set:

$$A = \{2, 4, 6, 8\}$$

$$B = \{d, e, s, k\}.$$



Venn diagram.

The second way is by using a rule:

C is the set of four first even natural numbers.

D is the set of letters of the word "desk".

Two sets are equal if they contain exactly the same elements. If we look closer on our sets **A** and **C** we can see that all elements of set **A** are the same as elements of set **C** (same goes for sets **B** and **D**).

$$A=C \quad \text{and} \quad B=D$$

If set **A** contains element '2', then we can tell that element '2' belongs to set **A**. We have a special symbol to write it down in a shorter way: $2 \in A$, $105 \notin A$. (What does this statement mean?)

Let's define several sets.

Set **W** will be the set of all words of the English language.

Set **N** will be the set of all nouns existing in the English language.

Set **Z** will be the set of all English nouns which have only 5 letters.

Set **T** = {"table"}. On a Venn diagram below name all these sets:



If all elements of one set at the same time belong to another set then we can say that the first set is a subset of the second one. We have another special symbol to write this statement in a shorter way: \subset .

$$T \subset Z \subset Y \subset W$$

If set V is defined as a set of all English verbs, can you draw a diagram for set V on the picture above? Can you tell subset of which set V is?

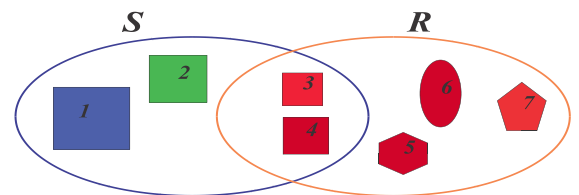
$$V \subset \underline{\hspace{2cm}}$$

$$V \not\subset \underline{\hspace{2cm}}$$

$$V \not\subset \underline{\hspace{2cm}}$$

$$V \not\subset \underline{\hspace{2cm}}$$

When several sets are defined it can happen that in accordance with all the rules we have implied several objects can belong to several sets at the same time. For example, on a picture below set S is a set of squares and a set R is a set of red figures.



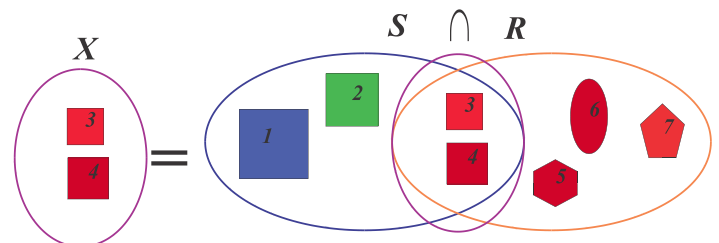
Figures 3 and 4 are squares and they are red, therefore they belong to both sets. Thus we can describe a new set X containing elements that belong to the set S as well as to the

set R . The new set was constructed by determining which members of two sets have the features of both sets. This statement also can be written down in a shorter version by using a special symbol \cap .

Such set X is called an **intersection** of sets S and R .

$$X = S \cap R$$

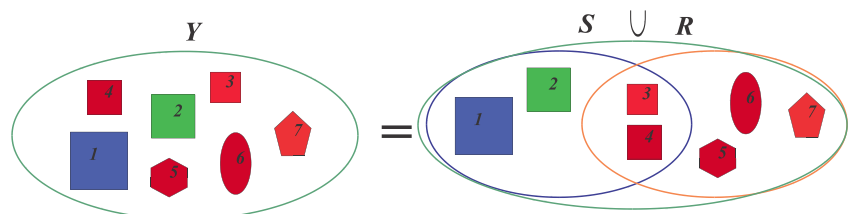
Another new set can be created by combining all elements of either sets (in our case S and R). Using



symbol \cup we can easily write the sentence: Set Y contains all elements of set S and set R :

$$Y = S \cup R$$

Such set Y is called a **union** of set S and R . Set which does not have any element is called an empty set. In math people use symbol \emptyset).



\in	element belongs to a set
\notin	element does not belong to a set
\subset	one set is a subset of another set
$\not\subset$	one set is not a subset of another set
\cap	intersection of two sets
\cup	union of two sets
\emptyset	empty set

Exercises:

1. $A = \{a, b, c\}$, $B = \{1, 2, 3, 4\}$. Write the intersection ($A \cap B$) and the union ($A \cup B$) of these two sets.

2. Put 4 elements in 2 sets (A and B) on the Venn so that



a. Each set contains 3 elements

b. One set contains 2 elements and another set contains 4

c. 4 and 3

d. 0 and 4

e. Each contains 4

f. Each contains 2



3. There are 20 students in a Math class. 10 students like apples and 15 students like pears.

Show that there are some students who like both apples and pears.

Assume that each student likes at least one of the fruits. (This means that each student like either apples, or pears, or both). How many students like both pears and apples?

Is it possible to determine if there any students who do not like apples and do not like pears? If yes, explain how you can do it. If no, demonstrate by giving examples.

4. The same Math class (with 20 students) forms a soccer team and a basketball team. Every student signs up for at least one team:

- 12 students play only soccer;
- 2 students play both soccer and basketball;

How many students play basketball only?



5. Students who participated in math coopetition had to solve 2 problems, one in algebra and another in geometry. Among 100 students 65 solved algebra problem, 45 solved geometry problem, 20 students solved both problems. How many students didn't solve any problem at all?
6. Among mathematicians every seventh is a philosopher, among philosophers every ninth is a mathematician. Are there more mathematicians or philosophers?
7. There are 2006 rose bushes in a garden. Peter watered a half of all bushes, Ann watered also a half of all bushes. 3 rose bushes were watered twice. How many bushes Peter and Ann didn't water at all.
8. 240 students from New-York and Seattle attended a math camp. Of the total number of students, 125 were boys. 65 boys were from New-York. There were 53 girls from Seattle. How many students came from New-York?
9. In 2 boxes there are 160 notebooks altogether. In one box there are 20 more notebooks than in the other. How many notebooks are there in each box?

Geometry.

A **definition** is a statement of the meaning of a something (term, word, another statement).

desk

noun

noun: **desk**; plural noun: **desks**

1. a piece of furniture with a flat or sloped surface and typically with drawers, at which one can read, write, or do other work.



onyms: **writing table, bureau, escritoire, secretaire, rolltop desk, carrel, workstation, worktable**

- o Music
a position in an orchestra at which two players share a music stand.
"an extra desk of first and second violins"
- o a counter in a hotel, bank, or airport at which a customer may check in or obtain information.
"the reception desk"

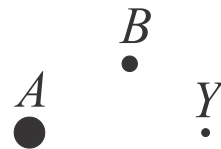
In mathematics everything (mmm,,, almost everything) should be very well defined. In our real life it is also very useful and convenient to agree about terms and concepts, to give them a definition, before starting using them just to be sure that everybody knows what they are talking about. Now we move to geometry.

Can we give a definition to a point? Can we clearly define what a point is? What a line is? What a plane is?

Mathematicians decided do not define terms "point", "straight line", and "plane" and to rely upon intuitive understanding of these terms.

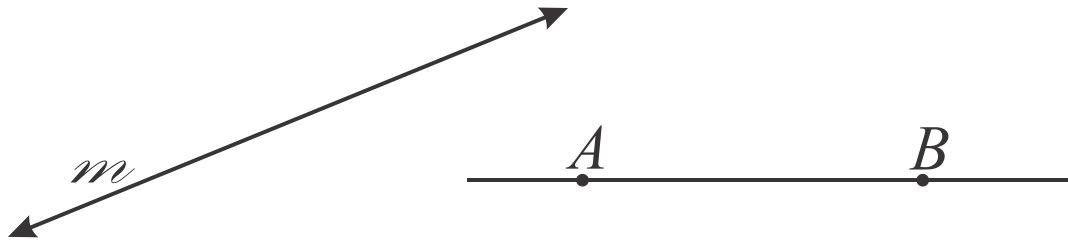
Point (an undefined term).

In geometry, a point has no dimension (actual size), point is an exact location in space. Although we represent a point with a dot, the point has no length, width, or thickness. Our dot can be very tiny or very large and it still represents a point. A point is usually named with a capital letter.



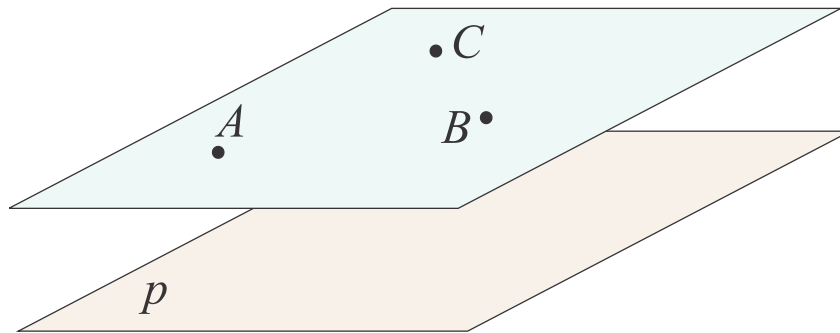
Line (an undefined term).

In geometry, a line has no thickness but its length extends in one dimension and goes on forever in both directions. Unless otherwise stated a line is drawn as a straight line with two arrowheads indicating that the line extends without end in both directions (or without them). A line is named by a single lowercase letter, *m* for example, or by any two points on the line, \overleftrightarrow{AB} or AB .



Plane (an undefined term).

In geometry, a plane has no thickness but extends indefinitely in all directions. Planes are usually represented by a shape that looks like a parallelogram. Even though the diagram of a plane has edges, you must remember that the plane has no boundaries. A plane is named by a single letter (plane p) or by three non-collinear points (plane ABC).



A line segment is a part of a straight line between two chosen points.
(A set of points of a straight line between two points.)
These points are called endpoints.

A ray is a part of a straight line consisting of a point (endpoint) and all points of a straight line at one side of an endpoint. Ray is named by endpoint and any other point, ray \overrightarrow{AB} or AB (where A is an endpoint)

Exercises:

1. Draw two segments AB and CD in such way that their intersect
 - a. by a point
 - b. by a segment

- c. don't intersect at all.
2. Using a ruler draw a straight line, put on it 3 points, A , B , and C so that 2 rays are formed, BC and BA .
 3. Draw two rays AB and CD in such way that their intersect
 - d. by a point
 - e. by a segment
 - f. by a ray
 - g. don't intersect at all
 4. On a straight line m points A , B , and C are marked. The length of a segment $|AB| = 1\text{ cm}$, the length of a segment $|BC| = 3\text{ cm}$. What is the length of the segment $|AC|$?
 5. The length of a segment $|AB| = 12\text{ cm}$. Point K marked 5 cm closer to point A than to point B . What is the distance $|AK|$?
 6. On the segment AB mark a point M . How many segments do we have on the picture? Mark another point P . How many segments do we have now? Mark a third point F . Count segments. How many segments will be if you mark 5 points? 10 points? 99 points?