Classwork

Distance, displacement, speed and velocity.

We started studying Physics. I believe that there are three major reasons why people do Physics. First, we need to know how the Universe works, and what is our place here. This urge, in my opinion, is one of the crucial features of the human mind. The second reason is practical: Physics made possible the creation of devices and gadgets around us. And, finally, it is so much fun to do experiments and solve problems! (Especially if you can check your solution experimentally).

We are surrounded by **physical phenomena**: sunrise, water flow, hurricanes, candle flame etc., etc., etc. There are so many of them that it is hardly possible to make a complete list. However, all the physical phenomena can be explained using a number of basic principles or **physical laws**. It was very difficult to reveal the laws behind a huge diversity of the physical phenomena. The first step includes **observations and experiments**. They are necessary to gather information about new and unexplained phenomena. Analyzing the information obtained, physicists try to find similar features between various phenomena and formulate the theory which explains the observations and the experiment results. The next step is to **design a special experiment** and try to **predict its result** using the new theory. If the prediction is correct, it indicates that the theory may be correct as well. So we can think how our new physical law can be used to make our life better.

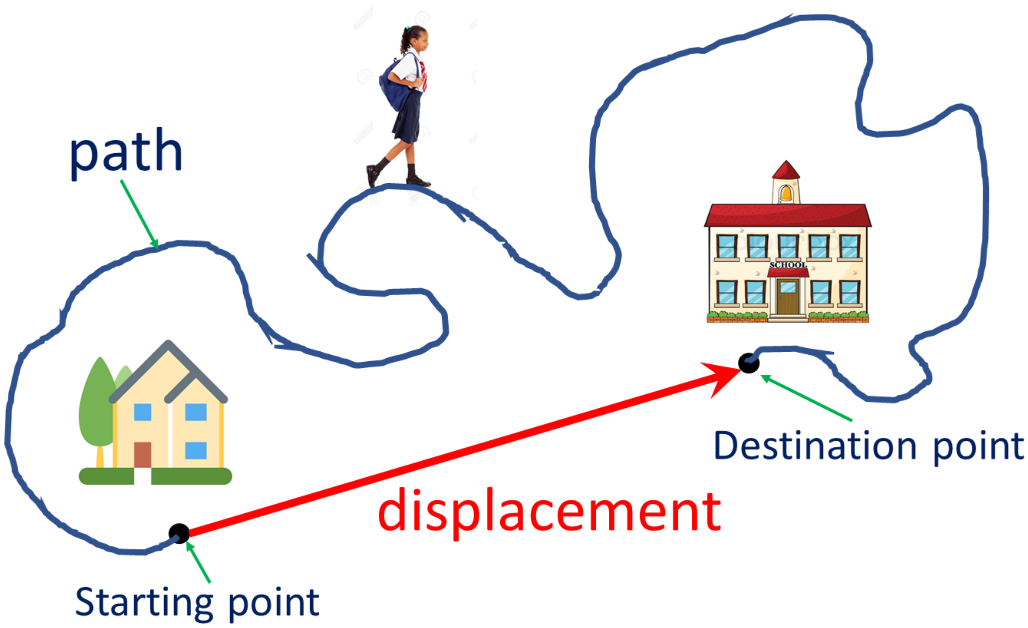
The process I described is generally correct but oversimplified: usually it takes much more than one experiment to check a complicated physical theory. One can hardly count how many experiments were needed to create a car, or, say, a GPS navigator.

No physical experiment is possible without **measurements**. When we are measuring, say, the length of the pencil, we are comparing the pencil with some standard length. This standard length is called **the unit of length**. The units were developed as a result of agreement between the people. Each physical quantity has units. Usually, there are several units for each physical quantity. For example the length can be expressed in meters, inches, miles, light years etc. That is why you always have to point out what unit you use to express physical quantity.

We also became familiar with two kinds of physical quantities. First kind includes the quantities which “consist” of just a magnitude, for example, time. Such quantities are called **scalar quantities or scalars.** The quantities from the second kind are described by both magnitude and direction. These quantities are called **vector** quantities. Examples of the vector quantities are force and velocity. **A vector quantity or parameter can be represented by an arrow.** The length of the arrow corresponds to the magnitude and the direction of the arrow corresponds to the direction of the vector parameter.

We know that the position of an object can be specified only with respect to some other object. For example, when I am saying that my house is in 5 miles, it usually means “my house is in 5 miles from my current position”. We can use more physical language to say that: “in a reference frame connected to my current position the distance to my house is 5 miles”.

An important physical quantity we discussed is **displacement**. This parameter describes the change in an object position. If the object was moved from one point to another, the displacement can be represented as an arrow connecting the initial and final positions.



The displacement does not depend on the shape of the path, passed by the object as long as the initial and final positions stay the same. If the initial and final positions coincide, the displacement is zero. Displacement is a vector.

In contrast to displacement, **distance** passed by the object depends on the object’s path. We can define the distance as the total length of the object’s path. Distance is scalar.

Speed is a *distance* passed per unit time. To find speed we have to divide the distance to the time, which required to pass the distance.

$$speed = \frac{distance}{time} \text{ , or}$$

$$s = \frac{d}{t}$$

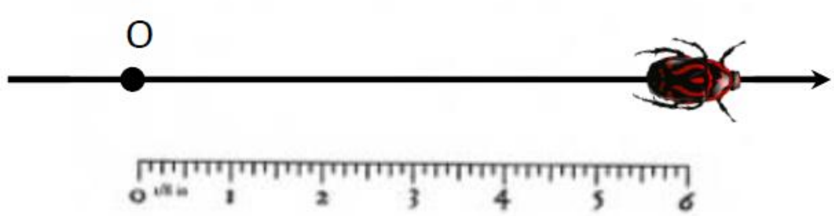
Speed is a scalar. It means that it is just a number and has no direction. As we mention speed the direction of the motion is not important for us. For example, a speed limit sign specifies the maximum speed independently on the direction of your motion. In contrast to speed, **the velocity is a vector**. The velocity is a displacement per unit time.

$$\overrightarrow{velocity} = \frac{\overrightarrow{displacement}}{time} \text{ , or}$$

$$\vec{v} = \frac{\vec{d}}{t}$$

The arrows over the characters show that the corresponding parameters are vectors. If the velocity of the object does not change, the motion is called ***uniform***. Since the velocity is a vector, it has, as we already know, both magnitude and direction. If the velocity does not change, both speed and direction of the motion remain constant (which means that they do not change as well). So, uniform motion is motion along a straight line. Motion along a straight line is called ***rectilinear motion***. Although any uniform motion is rectilinear, rectilinear motion is not necessarily uniform.

This year we will be mostly studying rectilinear motion. To specify the position of the object moving along a straight line we need a reference point. It is convenient to choose a point at the line of motion and calculate all the distances and displacements with respect to this point. We will call this point “origin” and mark with the character O.



Most of the motions around us are nonuniform. It means that the speed and /or velocity are changing during the motion. In this case we can introduce ***average speed*** **and** ***average velocity***. Average speed is the rate of *total* distance and time interval required to cover this distance.

$$\text{average speed} = \frac{\text{total distance}}{\text{total time}}$$

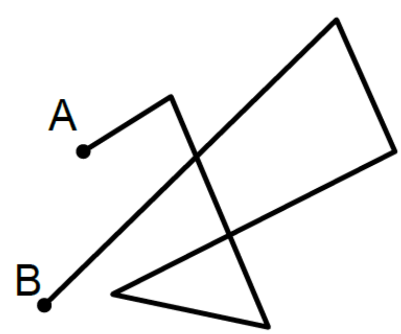
For example, you have to go for 1km. First you run, then stop for a while to take a break and, finally, you walk. It took 15 minutes to cover 1 km. The average speed in this case is:

$$\text{average speed} = \frac{\text{total distance} = 1\text{km} = 1000\text{m}}{\text{total time} = 15\text{min} = 15 \text{ x } 60\text{s} = 900\text{s}} \approx 1.11\frac{m}{s}$$

It means that instead of running, taking a rest and, finally, walking you just keep going with a uniform speed of 1,11m/s you will pass 1 km for the same time of 15min.

Homework:

1. A bug moves from point A to point B along the path shown below. Measure the total distance the bug passed and displacement. Draw the displacement vector.



2. The speed of the car is 36km/h (kilometers per hour). Recalculate the speed into meters per second (m/s).
3. A car passed 30km at the speed of 15m/s. Then the car turned back and spent 1 hour to pass 40 km. Find average speed and average velocity of the car? Make a picture.
4. Compare two speeds: 3 inch per second and 300cm per minute. (1 meter =100 cm).