AVERAGE SPEED AND ACCELERATION

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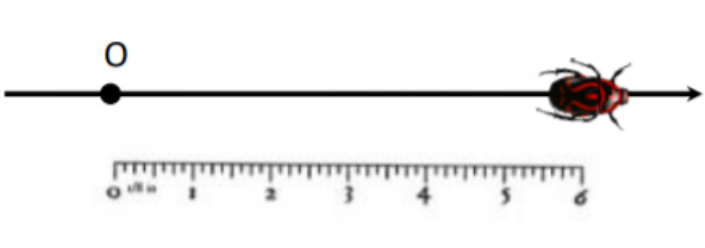
Theory recap

Last time we started discussing speed and velocity. We learned that if velocity of the object does not change, the motion is called *uniform*. If 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 an 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.



The direction from the origin to our right we will call positive. The opposite direction is negative. This choice is arbitrary. You may choose the positive direction as you wish. Positive or negative sign of the velocity or displacement will just indicate the direction of the motion. In contrast, speed and distance cannot be negative – they have no direction.

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 a ratio of total distance and time interval required to cover this distance:

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

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

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

It means that instead of running, taking a rest and, finally, walking you just keep going with a uniform speed of 1.11 m/s you will pass 1 km for the same time of 15 min.

Average velocity is a ratio of total **displacement** and time interval required to complete this displacement:

$$\overrightarrow{average\ velocity} = \frac{\overrightarrow{total\ displacement}}{total\ time}$$

For example, if at the end of a very long trip you returned to the starting point, your average velocity is zero, because your displacement is zero.

Introduction to acceleration. We also started discussing acceleration. In everyday life we use the word acceleration to describe increase of the speed of a moving object. Acceleration in physics has different meaning. It is change in *velocity* per unit time. Any time the speed and/or the direction of motion of an object changes we deal with accelerated motion. There are many examples of accelerated motion: a bike starting moving from rest, a car braking, any object falling. We know that any object (if we could neglect the air drag) falls down with acceleration of 10m/s^2 ($9.8\ \text{m/s}^2$, to be exact).

For rectilinear motion (along a straight line) if an object started with zero speed and during time t gained speed v, its' acceleration was

$$a = \frac{v}{t}$$

Homework

1. 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.

2. Imagine that you dropped a penny from the Empire State Building (please, never do it in real life!). Calculate the speed of the coin in 5 seconds.

Below is a bit more challenging problem.

***3.** Walker passed one half of the distance at the speed of 1m/s, the other half was passed at the speed of 0.5 m/s. What was the average speed of the walker?