Homework 1.

1. ***Measurements. Units. Distance and displacement.***

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.

Important note: *it is not possible to **add** and/or **subtract** the numbers corresponding to different physical quantities. You can **add** and **subtract** the numbers corresponding to the same physical quantity, but only if these numbers correspond to the same units. It is not possible, for example, to subtract inches from meters or add seconds and hours. However, as we will learn later, it is possible to **multiply** and/or **divide** the numbers corresponding to different physical quantities.*

We also became familiar with two kinds of physical quantities. First kind includes the quantities which are “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 or **vectors**. 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 started our physics course from mechanics. To my opinion, this is the

most important part of the Physics. The mechanics describes the effect of forces on various objects. Later we will discuss in details what the force is. But even before this discussion it is intuitively clear that application of force generally leads to change of the position of the objects. One of the most important problems of the mechanics is to describe the position of the object, to which the force is applied, at any moment of time.

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 the displacements, the *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, velocity *average speed and average velocity.*

We started discussing speed and velocity. ***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.

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

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

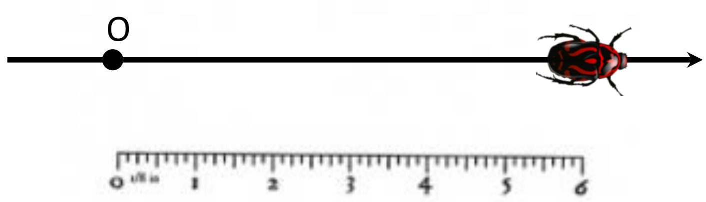
Speed is a scalar. It means that it is just a number and has no direction. As we mention speed the direction of the motion is not important for us. For example, a speed limit sign specifies the maximum speed independently on the direction of your motion. In contrast to speed, the velocity is a vector.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

$$\overrightarrow{velocity} = \frac{\overrightarrow{displacement}}{time}$$, 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.



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 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.

Average velocity is a rate of total ***displacement*** and time interval required to complete this displacement.

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

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.

Problems.

1. A rubber ball falls 5 feet down, hits the floor and bounces 3 feet up. Find the distance passed by the ball and the displacement. Make a drawing and show the displacement of the ball.
2. The speed of the car is 36km/h (kilometers per hour). Recalculate the speed into meters per second (m/s).
3. Is it possible that the distance passed by someone is less that the displacement? Explain your answer.

4. The velocity of an object is changing. Does it necessarily mean that the speed of the object is changing too? Explain your answer.

5. 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.

   Below is a bit more challenging problem.

6. Walker passed one half of the distance at the speed of 1m/s, the other half was passed at the speed of ½ m/s. What was the average speed of the walker?