Homework 3

Velocity composition

Last class we discussed the velocity addition rule. What are the most important things we have learned?

1. The velocity can only be measured with respect to an object. Any time we mention the velocity, we have to specify with respect to what object this velocity is measured. When we say that the velocity of the car is 50 km/h it usually means that this is the velocity with respect to the ground. A physicist would say that the velocity is 50km/h in the *ground's reference frame*. The velocity (the speed and the direction of motion) depends on the choice of the reference frame.

2. The velocity addition rule is given below:

If the object B moves with respect to the object A at the velocity $\overrightarrow{V_1}$ *and the object C moves with respect to the object B at the velocity* $\overrightarrow{V_2}$*, then the object C moves with respect to the object A at the velocity* $\vec{V}=\vec{V}_1+\overrightarrow{V_2}$.

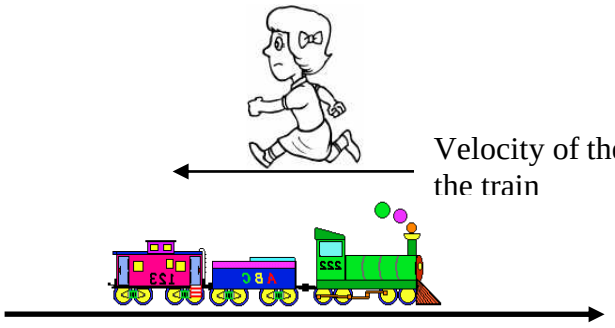
The arrows on top of the velocity symbols mean that the velocities have direction. In the case of motion along a straight line they are "left to right" and "right to left" or "plus" and "minus". The sign "plus" or "minus" will be chosen depending on the velocity direction. After we have chosen correct signs we can drop the arrows.

Please read the example below:

Problem: *A girl is walking in the moving train in the direction opposite to the train's motion. You are watching the passing train staying at the station. The velocity of the girl with respect to the train is 1m/s, the velocity of the train with respect to the ground is 36 km/h. Find the velocity of the girl with respect to you.*

Solution:

1. *Make a picture:*



Velocity of the girl with respect to the train

Velocity of the train with respect to the station

2. *Choose the" positive" direction. You have two options:" left to right" or" right to left". You can pick up any one – the result will not depend on your choice. For this problem I choose left to right. From now on, all the velocities directed left to right are positive, all the velocities "looking" in the opposite directions are negative. The velocity of the train is positive; the velocity of the girl with respect to the train is negative, because it "looks" in the opposite direction.*
3. *According to the velocity composition rule:*
   Velocity of the girl with respect to the station (we denote it as $\vec{V}gs$*) = velocity of the girl with respect to the train (*$\vec{V}gt$*)* plus *velocity of the train with respect to the station (*$\vec{V}ts$*).Or*

$$\vec{V}gs = \vec{V}gt + \vec{V}ts.$$

4. *According to the problem,* $\vec{V}_{gt}$= - 1m/s (it is negative), $\vec{V}_{ts}$= 36km/h=10m/s (it is positive). So,
5.

$$\vec{V}_{gs}\text{= -1m/s +10m/s = 9m/s}$$

The problem is solved. The answer is positive 9m/s. It means that the girl is moving left to right (since the result is positive) at a speed of 9m/s.

Now the homework problems:

1. Choose the direction right to left as the "positive" and solve the problem given above. Is the result changed?

2. A boat moves up the river (against the water flow).The speed of the boat with respect to the water is 5m/s, the speed of the water with respect to the riverbanks is 1m/s. Find the velocity of the boat with respect to the riverbanks.

3. Two cars a moving along a straight road toward each other from different towns. The speed of the right car is 72km/h, the speed of the left car is 36km/h. Find the velocity of the right car with respect to the left car.