Dr. Mitch Hoselton 9/10/2003
Physics: An Incremental Development, John H. Saxon, Jr.

Lesson #4: Vectors Part 3

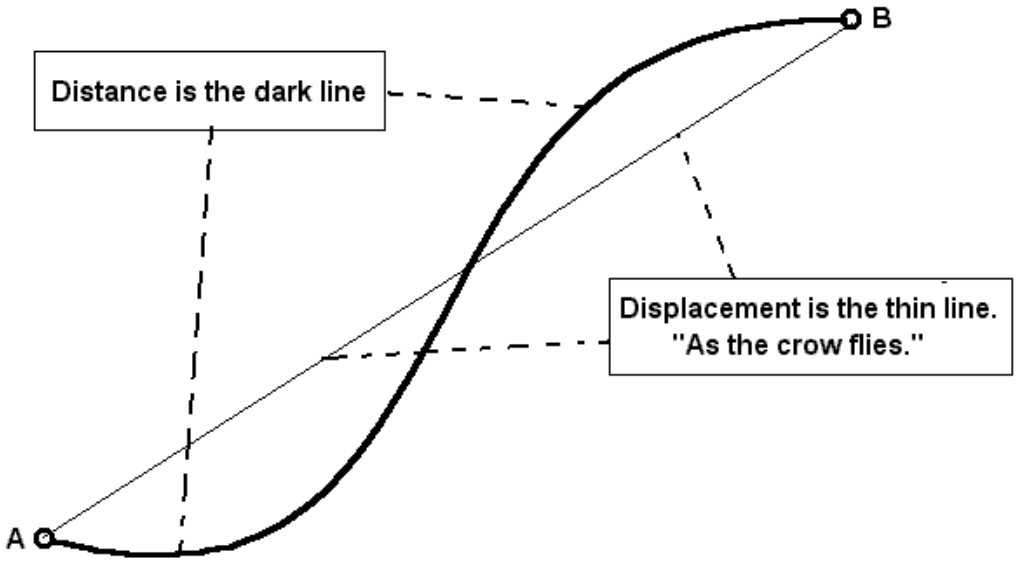
Average Speed and Average Velocity

Like displacement, velocity is a vector quantity. Speed is something else. Speed is not a vector. Speed is what your car's speedometer reads. It contains no directional information. It only tells you how fast your are going but not which direction you are going. In measuring speed your direction can change at random and the speed tells you nothing about those directional changes.

The SI unit of speed is m/s = meters per second. To determine the average speed of a vehicle we take the total distance traveled along whatever circuitous path its been following and divide that by the time taken to move that distance.

The SI unit of velocity is also m/s. The velocity contains directional information along with the speed information. The average velocity over a time interval is the displacement divided by the time taken to move through that displacement.

To understand the difference between average speed and average velocity, you really need to look first at the difference between distance and displacement. Here is a diagram that should help.



Distance from A to B is measured along the winding, curvy path, while displacement from A to B is measured "as the crow flies" from the starting point to the ending point of the trip. IF the path happened to be a straight path connecting the beginning point to the ending point, the distance would equal the magnitude of the displacement vector. In that case, too, the average speed would be equal to the magnitude of the average velocity vector. The distance can never be less than the magnitude of the displacement vector, however.

IN GENERAL, the distance will be larger than the magnitude of the displacement vector.

Therefore, the average speed is always at least equal to and in general it is greater than the magnitude of the average velocity vector.

It seems that we may be giving up information about the details of the winding, curvy path when we use the average velocity. This does not have to be the case, however. For one thing, there is nothing stopping us from looking at smaller time intervals. If we take the average velocity over many short paths that collectively add up to this longer path we will have even more information than we could get from the average speed. We will, for example, have all the directional information about the twists and turns as well as all the information about how fast or how slow that vehicle moved while negotiating each turn.

Thus, while average speed may seem more intuitive, the average velocity is a concept that we can develop into a more powerful tool later.

To help you keep these terms clear in your mind, remember this little tale.

Imagine you stayed the night in a small inn near the top of hill in the Spanish Pyrenees. Before setting off in the morning, you take out a pair of binoculars and your host points out your destination for lunch that afternoon down in the valley.

"That's not so far," you tell your host, who merely smiles.

The road you are driving is winding and the switchbacks force you to slow down frequently. The road is so circuitous that after a while you have no idea where you are or where you are heading.

About the time your odometer says that you've traveled a distance of 60 kilometers you reach your destination. That was awful you think quietly to yourself. That took almost 3 hours and my average speed was only 20 km/hr.

But that's not the worst of it. When you viewed the village that morning it was only 12 km away from where you were standing and was easily visible through the binoculars. That means your total displacement for this trip is 12 km and your average velocity was therefore only 4 km/hr.

Remember that distance goes with speed while displacement goes with velocity.

Remember too that displacement and velocity are vectors.

{Warning – Life is not always this simple. You cannot absolutely rely on the correct use of these two words. People often say "distance" when they mean "displacement." When you know the motion is in a straight line, you need to substitute displacement even when someone says distance. They are numerically the same for motion in one dimension.}