PhyzGuide: Instantaneous Velocity, Average Velocity, and Relative Velocity

INSTANTANEOUS SPEED AND VELOCITY

The **instantaneous velocity** of a particle is the exact velocity of the particle at a given point in time. The speedometer on your car measures instantaneous speed (remember, velocity involves speed and direction, and a speedometer does not measure direction).

Suppose you drove from Rio Americano to Sunrise Mall. You traveled a distance of 15 miles, and it took 30 minutes. During the trip, your speed would vary quite a bit: fast along Hwy. 50, slow crawling up along Sunrise Boulevard. The direction of travel would change throughout the trip, as well: east and northeast along Hwy. 50, north along Sunrise. At some point along the way, you notice the speedometer reads 55mi/hr (hopefully, this was when you were on Highway 50, *not* American River Drive). Your instantaneous **speed** at that point was v = 55mi/hr. If your compass was reading due East at that point, your instantaneous velocity was **v** = (55mi/hr, East). But if it took 30 minutes to go 15 miles, wasn't the "total speed" 15mi/30min = 0.5mi/min = 30 mi/hr? The "total direction" was northeast, also. So what does **v** = (30mi/hr, NE) represent? This brings us to the next section....

AVERAGE SPEED AND VELOCITY

In the example above, **v** = (30mi/hr, NE) represents **average velocity**. The average speed of the car during the trip was 30mi/hr. The car may not have ever traveled at exactly 30mi/hr for any appreciable period of time during the trip, but average speed is defined as total distance divided by total time, so it is independent of whatever instantaneous speeds were involved in the trip. The direction of average velocity is the net direction for the entire trip.

RELATIVE SPEED AND VELOCITY

As you were cruising along US 50 on your ride to the mall, you noticed some "fine (babes"/dudes") in a car next to you. To prolong the observation of these "fine (babes"/dudes"), you matched their speed. At that point, the speed of your car (1) relative to their car (2) was v_{12} = 0mi/hr. The speed of their car (2) relative to yours (1) was v_{21} = 0mi/hr. The speed of both cars relative to the CHP officer (3) sitting stationary at the side of the road might be $v_{13} = v_{23}$ = 55mi/hr. Relative to your car, the speed of a car (4) going the other way on Hwy. 50 might be v_{41} = –110mi/hr (the negative indicates the other car is traveling in the opposite direction from you).