VELOCITY

Drivers should know how fast they are moving-they have speedometer to tell them their speed at any instant time.Traffic police can use a radar speed gun to give them an instant readout of another vehicle's speed.Alternatively traffic police may time a car between two fixed points on the road. Knowing the distance between the two points,they can calculate car's speed.

SPEED

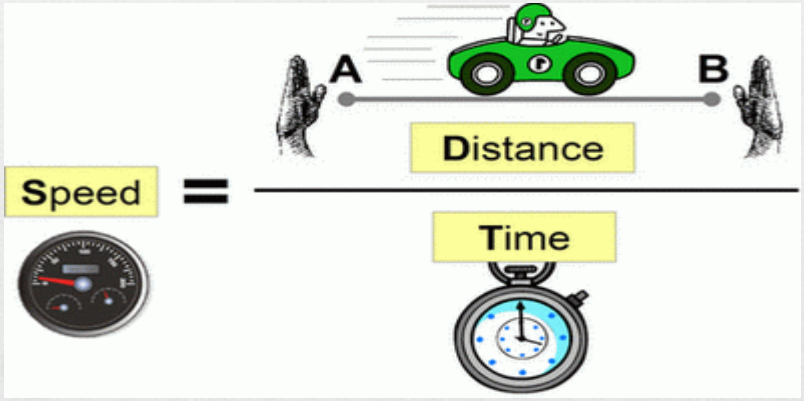
Speed is a scalar quantity that refers to "how fast an object is moving." Speed can be thought of as the rate at which an object covers distance. A fast-moving object has a high speed and covers a relatively large distance in a short amount of time. Contrast this to a slow-moving object that has a low speed; it covers a relatively small amount of distance in the same amount of time. An object with no movement at all has a zero speed.

Doubling one's speed would mean doubling one's distance traveled in a given amount of time. Doubling one's speed would also mean halving the time required to travel a given distance. If you know a little about mathematics, these statements are meaningful and useful.

Speed is directly proportional to distance when time is constant: v ∝ s (t constant)

Speed is inversely proportional to time when distance is constant: v ∝ 1/t (s constant)

Combining these two rules together gives the definition of speed in symbolic form $v = s/t$



Don't like symbols? Well then, here's another way to define speed. Speed is the rate of change of distance with time.

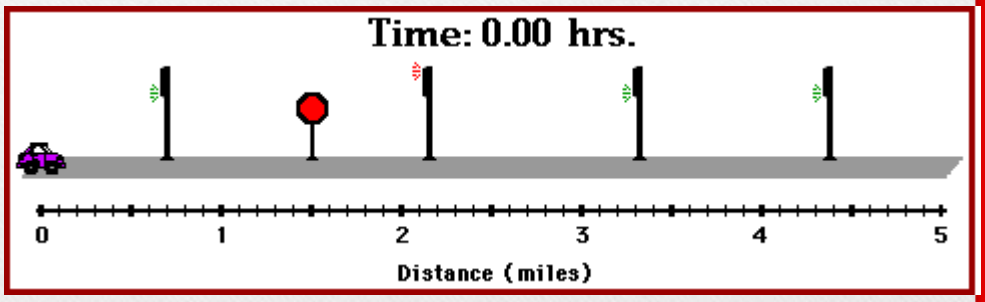
AVERAGE SPEED

The **average speed** of an object over a given time interval is the total distance traveled divided by the total time elapsed:

$$average\ speed = \frac{total\ distance}{total\ time} \Rightarrow v_{av} = \frac{s}{t}$$

Because total distance and total time are always positive, the average speed will be positive, also. The definition of average speed completely ignores what may happen between the beginning and the end of the motion.

example:
Suppose that during your trip to school, you traveled a distance of 5 miles and the trip lasted 0.2 hours (12 minutes). The average speed of your car could be determined as



$$average\ speed = \frac{5\ miles}{0{,}2\ hours} = 25\frac{miles}{hours}$$

On the average, your car was moving with a speed of 25 miles per hour. During your trip, there may have been times that you were stopped and other times that your speedometer was reading 50 miles per hour. Yet, on average, you were moving with a speed of 25 miles per hour.

During a typical trip to school, your car will undergo a series of changes in its speed. If you were to inspect the speedometer readings at regular intervals, you would notice that it changes often. The speedometer of a car reveals information about the instantaneous speed of your car. It shows your speed at a particular instant in time.

In the SI system, distance is measured in meter(m), and time in second(s). Therefore, speed is in meter per second(m/s).

Table shows the different units that may be used in calculation of speed.

Quantity	SI unit	Other units	
distance	metre m	kilometre km	miles
time	second s	hour h	hour h
speed	meter per second m/s	kilometres per hour km/h	miles per hour mph

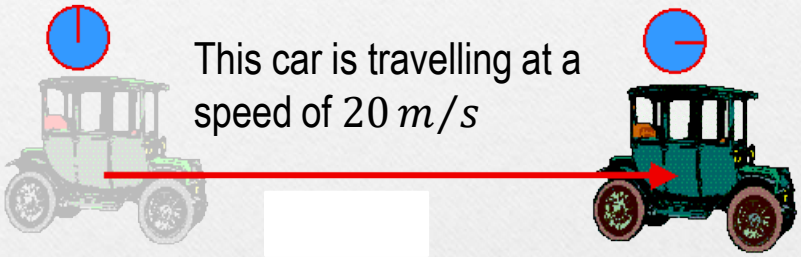
AVERAGE VELOCITY

Average speed and instantenous speed are scalar quantities that do not take into account the direction in which the object moves. Speed and direction are combined in another quantity, called velocity. The direction of the velocity vector is simply the same as the direction that an object is moving.

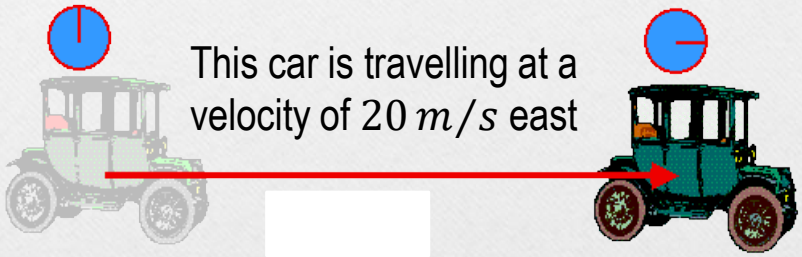
The average velocity $\vec{v}_{avd}$ during a time interval Δt is the displacement $\Delta\vec{r}$ divided by Δt:

$$average\ velocity = \frac{displacement}{time\ interval} \Rightarrow \vec{v}_{avd} = \frac{\Delta\vec{r}}{\Delta t}$$

Speed is simply how fast you are traveling



Velocity is speed in a given direction



Unlike speed,which is always a positive number, velocity is positive (+) or negative (-) based on direction of motion. First choose positive (+) direction; then v is positive if motion is with that direction, and negative if it is against that direction. The average velocity is always less than or equal to the average speed of an object.

Example: If I drive from my home to my workplace (and then defining my positive direction in that way), then my velocity is positive if I go to work, but negative when I go home from work.

Unit for velocity is meter per second (m/s).

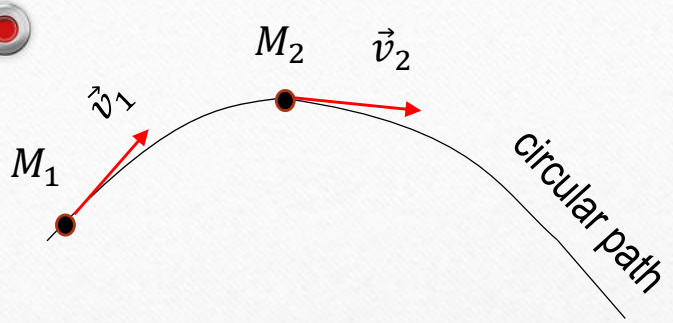
INSTANTANEOUS VELOCITY

The instantaneous velocity is obtained from the average velocity by shrinking the time interval closer and closer to 0. For example, assume you have been observing a runner racing along a track. Table gives the values: the time intervals. displacements, and average velocity of the runner

t_1 to t_2 (s)	Δt (s)	Δr (m)	v_{avd} (m/s)
0.00 to 2.00	2.00	+8.00	+4.00
0.00 to 1.00	1.00	+3.00	+3.00
0.00 to 0.50	0.50	+1.25	+2.50
0.00 to 0.20	0.20	+0.44	+2.20
0.00 to 0.10	0.10	+0.21	+2.10
0.00 to 0.01	0.01	+0.02	+2.00

With some degree of confidence we can state that the instantaneous velocity of the runner was +2 m/s at the time 0.00 s. As Δt dwindles, the average velocity $\langle\vec{v}\rangle$ approaches a limiting value, which is the velocity v at that instant (instantaneous velocity).

$$\vec{v} = \frac{\Delta\vec{r}}{\Delta t}, \Delta t \to 0$$



The direction of the instantaneous velocity vector is along a line that is tangent to the object's path and in the direction of its motion.

Typical Velocity Magnitude	
A snail's pace	$10^{-3}\,m/s$
A brisk walk	$2\,m/s$
Fastest human	$11\,m/s$
Freeway speeds	$30\,m/s$
Sound in air	$341\,m/s$
Random motion of air molecules	$500\,m/s$
Fastest airplane	$1000\,m/s$
Orbiting communications satellite	$3000\,m/s$
Electron orbiting in a hydrogen atom	$2 \cdot 10^{6}\,m/s$
Light traveling in a vacuum	$3 \cdot 10^{8}\,m/s$

PROBLEMS

1. For the first 5s, cyclist crossed 40m, then for 10s he crossed 100m, and for last 5s another 20 m. Find the average speed of the cyclist on each part of road as well as on all road.
2. During a certain time period, a car travelled a distance of 21.6 km at a speed of 36km/h. Then, it was travelling twice as fast over the same amount of time. What was the total distance covered and the average speed of the car on that road?
3. A cyclist covers a lap of 2.5 km long track in 5 min. How long will it take him to cover the second lap, so the average speed (for both laps) is 35 km/h?
4. A train travel at a speed of $54\,\frac{km}{h}$ during the first half of time, and $70\frac{km}{h}$ during the second half of time. What is the average speed of the train for all time of motion?
5. A train covers half of a distance at a speed of $72\,\frac{km}{h}$, and other half with speed $36\frac{km}{h}$. What is the average speed of the train on all road?
6. Formula 1 driver Sebastian Fetel won in 2015 Formula 1 Grand Prix in Hungary.. During the first thirty laps on the track "Hungaroring" Fetel drove with an average speed of 172km/h. During the second thirty laps he average speed of 167km/h, while the final 10 laps he drove with an average speed of 177km/h. What was the overall average speed of Fetel's car in this race?