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If a particle travels distances $s_1, s_2, s_3, \ldots$ with speeds $v_1, v_2, v_3, \ldots$, then

Average speed $= s_1 + s_2 + s_3 + \ldots / (s_1 / v_1 + s_2 / v_2 + s_3 / v_3 + \ldots)$

If particle travels equal distances ($s_1 = s_2 = s$) with velocities v_1 and v_2, then

Average speed $= 2 v_1 v_2 / (v_1 + v_2)$

If a particle travels with speeds $v_1, v_2, v_3, \ldots$, during time intervals $t_1, t_2, t_3, \ldots$, then

Average speed $= v_1t_1 + v_2t_2 + v_3t_3 + \ldots / t_1 + t_2 + t_3 + \ldots$

If particle travels with speeds v_1, and v_2 for equal time intervals, i.e., $t_1 = t_2 = t_3$, then

Average speed $= v_1 + v_2 / 2$

When a body travels equal distance with speeds V_1 and V_2, the average speed (v) is the harmonic mean of two speeds.

$2 / v = 1 / v_1 + 1 / v_2$

Instantaneous Speed

When an object is travelling with variable speed, then its speed at a given instant of time is called its instantaneous speed.

Instantaneous speed $= \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t} = \frac{ds}{dt}$

Velocity

Tlie rate of change of displacement of an object in a particular direction is called its velocity.

Velocity = Displacement / Time taken

Its unit is m/s.

Its dimensional formula is $[M^0T^1]$.

It is a vector quantity, as it has both, the magnitude and direction.

The velocity of an object can be positive, zero and negative.

If an object undergoes equal displacements in equal intervals of time, then it is said to be moving with a uniform velocity.

Non-uniform or Variable Velocity

If an object undergoes unequal displacements in equal intervals of time, then it is said to be moving with a non-uniform or variable velocity.

Relative Velocity

Relative velocity of one object with respect to another object is the time rate of change of relative position of one object with respect to another object.

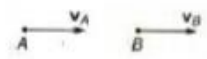
Relative velocity of object A with respect to object B

$V_{AB} = V_A - V_B$

When two objects are moving in the same direction, then

$\mathbf{v}_{AB} = \mathbf{v}_A - \mathbf{v}_B$

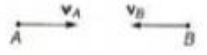
or $v_{AB} = v_A - v_B$



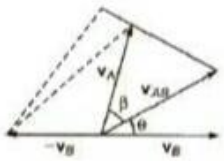
When two objects are moving in opposite direction, then

$\mathbf{v}_{AB} = \mathbf{v}_A + \mathbf{v}_B$

or $v_{AB} = v_A + v_B$



When two objects are moving at an angle, then



$v_{AB} = \sqrt{v_A^2 + v_B^2 - 2v_A v_B \cos\theta}$

and $\tan\beta = v_B \sin\theta / v_A - v_B \cos\theta$

Average Velocity

The ratio of the total displacement to the total time taken is called average velocity.

Average velocity = Total displacement / Total time taken

Note:- dimensional formula of speed-LT^-1.