MOTION

ACCELERATION

Acceleration

Acceleration is defined as

The rate of change of velocity with respect to time.

Acceleration is a vector quantity as it has both magnitude and direction. It is also the second derivative of position with respect to time or it is the first derivative of velocity with respect to time.

Acceleration Formula

Acceleration formula is given as:

$$\text{acceleration} = \frac{(\text{Finalvalocity}) - (\text{Innitialvelocity})}{\text{Time}}$$

$$\text{acceleration} = \frac{\text{changeinvelocitry}}{\text{time}}$$

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{\Delta v}{t}$$

Where,

a is the acceleration in $m.s^{-2}$

vf is the final velocity in $m.s^{-1}$

vi is the initial velocity in $m.s^{-1}$

t is the time interval in s

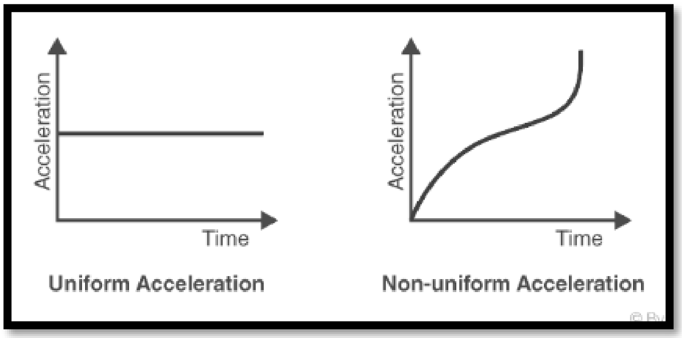
Δv is the small change in the velocity in $m.s^{-1}$

Unit of Acceleration

The SI unit of acceleration is given as:

SI unit m/s^2

Types of Acceleration



Uniform and Non-uniform Acceleration

So, can we have a situation when speed remains constant but the body is accelerated? Actually, it is possible in a circle where speed remains constant but since the direction is changing hence the velocity changes, and the body is said to be accelerated.

Average Acceleration

The average acceleration over a period of time is defined as the total change in velocity in the given interval divided by the total time taken for the change. For a given interval of time, it is denoted as $\bar{a}$.

Mathematically,

$$\bar{a} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

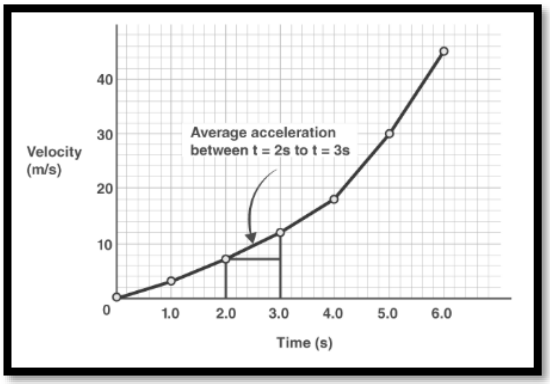
Where v_2 and v_1 are the instantaneous velocities at time t_2 and t_1 and $\bar{a}$ is the average acceleration.

Instantaneous Acceleration

Instantaneous acceleration is defined as

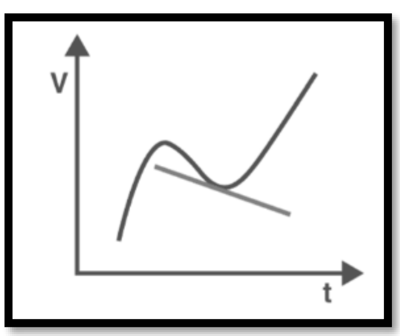
The ratio of change in velocity during a given time interval such that the time interval goes to zero.

Velocity-Time Graph

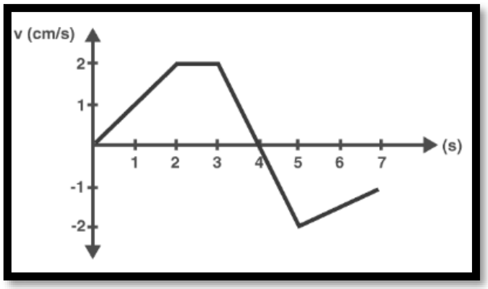


Average acceleration: In the velocity-time graph shown above, the slope of the line between the time interval t_1 and t_2 gives the average value for the rate of change of velocity for the object during the time t_1 and t_2.

Instantaneous acceleration: In a velocity-time curve, the instantaneous acceleration is given by the slope of the tangent on the v-t curve at any instant.



Positive, Negative and Zero Acceleration



Consider the velocity-time graph shown above. Here, between the time intervals of 0-2 seconds, the velocity of the particle is increasing with respect to time; hence the body is experiencing a positive acceleration as the slope of the v-t curve in this time interval is positive.

Between the time intervals of 2-3 seconds, the velocity of the object is constant with respect to time; hence the body is experiencing zero acceleration as the slope of the v-t curve in this time interval is 0.

Now, between the time intervals of 3-5 seconds, the velocity of the body is decreasing with respect to time; hence the body experiences a negative value of the rate of change of velocity as the slope of the v-t curve in this time interval is negative.

Acceleration Example

Q. What will be the acceleration of an object which moves with uniform velocity?

Ans: Given,

The velocity is uniform; therefore, the initial and final velocities are equal and is given as V.

∴From definition, acceleration is given as:

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{0}{t}$$

$$a = 0$$