Linear motion

Terms used

Displacement is the distance moved by a body in a specific direction

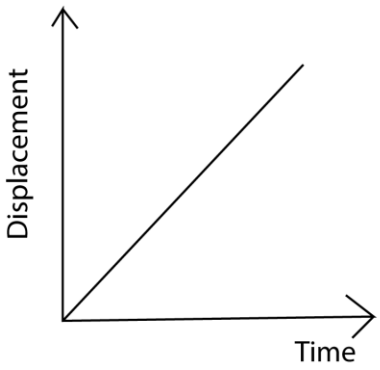
Velocity is the rate of change of displacement

Uniform velocity is the constant rate of change of displacement

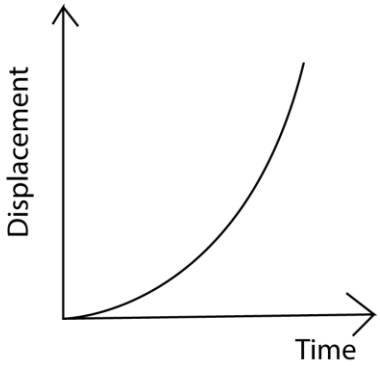
Acceleration is the rate of change of velocity.

Displacement time graphs

(i) Uniform velocity

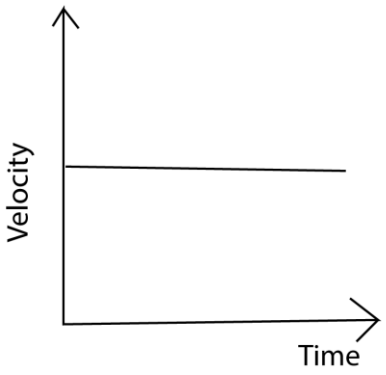


(ii) Uniform accelaration

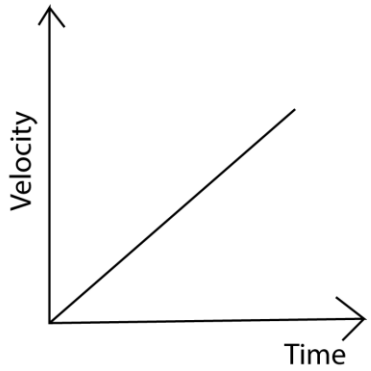


Velocity time graph

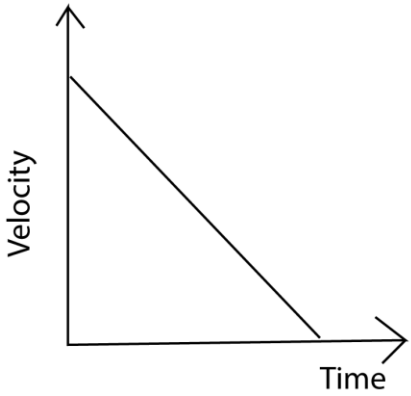
(i) Uniform velocity



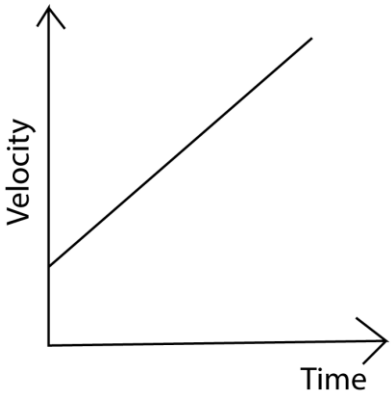
(ii) Uniform accelaration



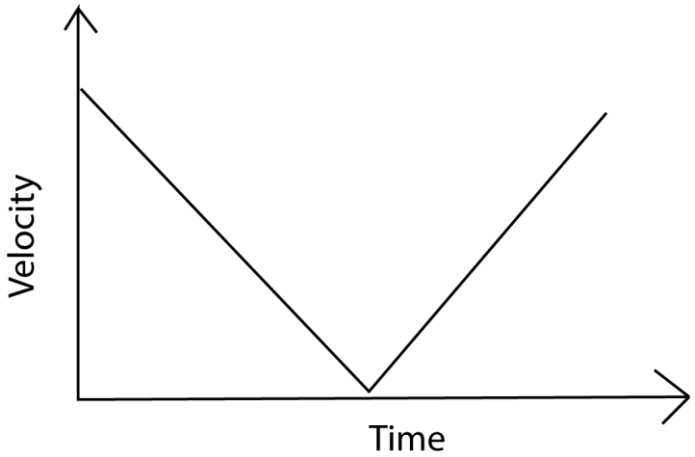
(iii) Uniform reterdation



(iv) Uniform accelaration where initial velocity is not zero



(v) For body thrown vertically upwards then falls afterwards with a uniform acceleration



Note: when velocity is uniform/constant or maximum, acceleration is zero

When the body starts from rest, initial velocity, u=0

When a body comes to the rest, the final velocity, v = 0

Equations of motion

Usual symbols

u – initial velocity

v- final velocity

s – displacement

a – acceleration

t – time

If a body's velocity changes from u to v in time t, then

(a) $\mathbf{a = \frac{change\ in\ velocity}{time} = \frac{v-u}{t}}$

or

$v = u + at$ ..... (i)

As the body's velocity increases steadily

Average velocity $= \frac{v+u}{2}$

(b) Displacement, s = averages velocity x time

$= \frac{v+u}{2}t$

But $v = u + at$

$s = \frac{(u+at+u)t}{2}$

$s = \frac{(2u+at)t}{2}$

$s = ut + \frac{1}{2}at^2$ ..... (ii)

From, $s = \frac{v+u}{2}t$

But $v = u + at$

$t = \frac{v-u}{a}$

$s = \frac{v+u}{2}\ x\ \frac{v-u}{a}$

$v^2 = u^2 + 2as$ .....(iii)

Example 1

A motorist travelling at constant speed of 50kmh^{-1} passes a motor cyclist starting of in the same direction. If the motorist maintains a constant acceleration of 2.8m/s^2,

(a) Calculate the time taken by the motorist to catch up with the motorist.

Motorist

u_1 =50km/hr $= \frac{50\ x\ 1000}{3600} = \frac{125}{9} ms^{-1}$

Distance moved by motorist, $s = \frac{125t}{9}\ m$

Where t = time taken by motorcyclist to catch up with the motorist

Distance s moved by motorcyclist = $0 + \frac{1}{2} \, x \, 2.8t^2$

It implies that

$\frac{125t}{9} = \frac{1}{2} \, x \, 2.8t^2$

t = 9.9s

(b) Speed of motorist as he overtakes the motorist

v = u + at = 0 + 9.9 x 2.8 = $27.8ms^{-1}$

Examples 2

A motor car moving with uniform acceleration covers 5.5m in the 4^{th} second and 9.5m in the 8^{th} second in its motion. Find its acceleration and the initial velocity.

Solution

From $s = ut + ½ at^2$

Distance covered in 4^{th} second = (distance covered in first 4seconds – distance covered in first 3 second)

$5.5 = (4u + ½ a \times 4^2) – (3ut + ½ a \times 4^2)$

$11 = 2u + 7a$ …….. (a)

Distance covered in 8^{th} second = (distance covered in first 4seconds – distance covered in first 3 second)

$9.5 = (8u + ½ a \times 8^2) – (7ut + ½ a \times 7^2)$

$19 = 2u + 15a$ …….. (b)

Solving: $a = 1ms^{-2}$; $u = 2ms^{-1}$