KINEMATICS

Motion

- **Distance:** the total length between two points
- **Speed:** the total distance travelled per unit of time
- **Displacement:** the distance of an object from a fixed point in a specified direction
- **Velocity:** the rate of change of displacement of an object
- **Acceleration:** the rate of change of velocity of an object
- **Equation:**

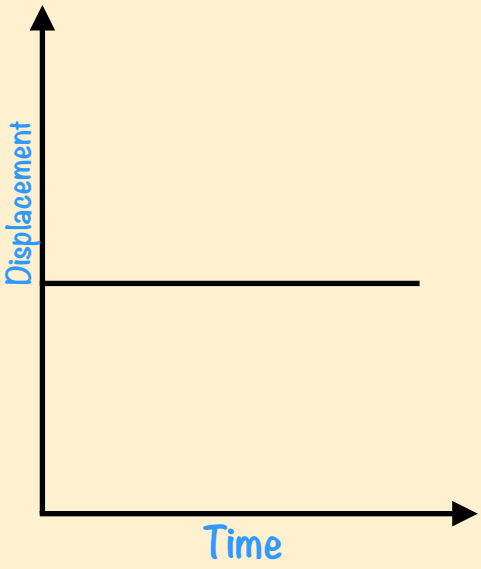
$$Velocity = \frac{change\ in\ displacement}{Time\ taken} = \frac{\Delta s}{\Delta t}$$

$$Acceleration = \frac{change\ in\ velocity}{Time\ taken} = \frac{\Delta V}{\Delta t}$$

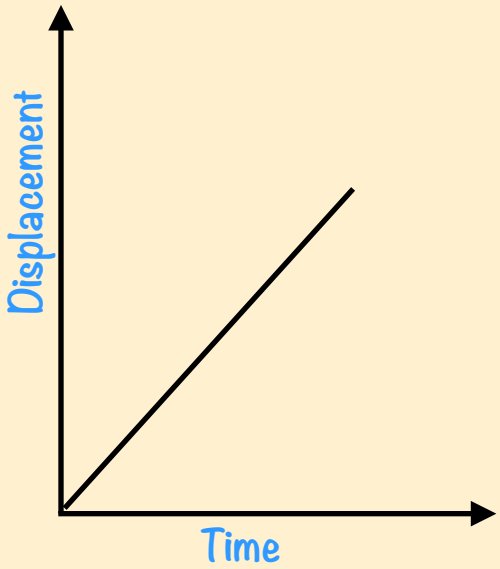
Motion Graph

Displacement-Time graph:

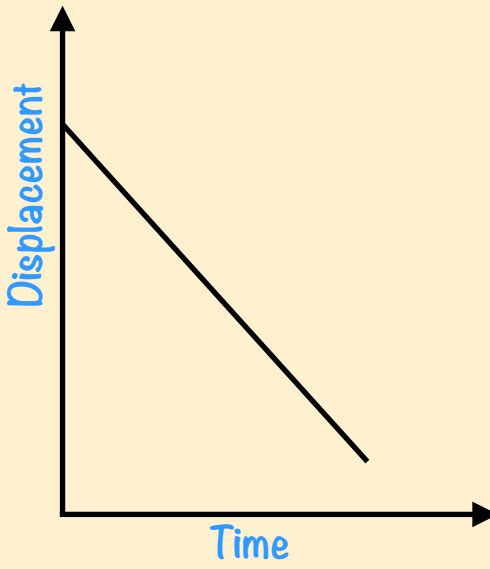
- Slope equals velocity.
- The y- intercept equals the initial displacement.
- A straight line represents a constant velocity.
- A curve line represents an acceleration.
- A positive slope represents motion in positive direction.
- A negative slope represents motion in negative direction.



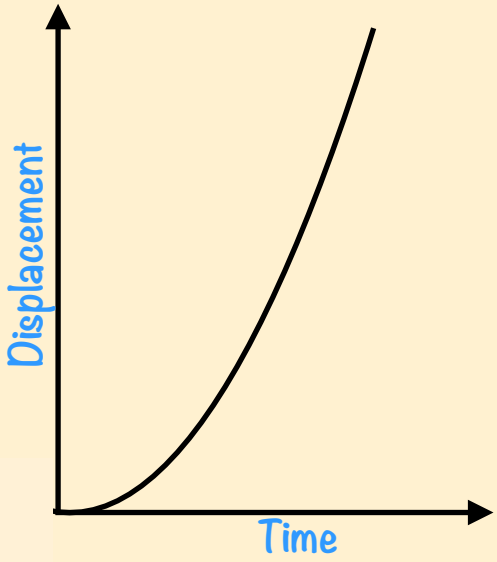
Displacement- time graph with zero velocity.(i.e the object is at stationary)



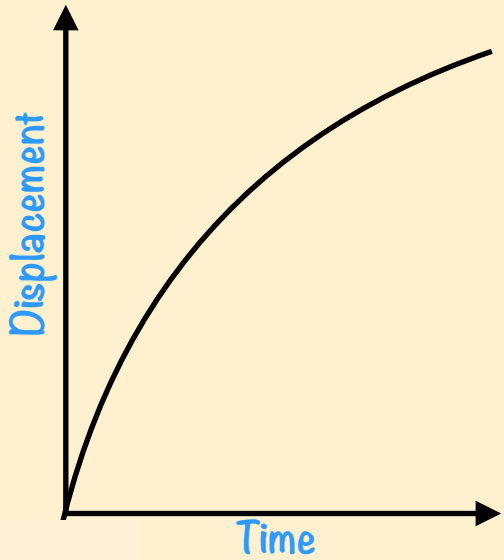
Displacement- time graph with constant velocity and moving away from observer.



Displacement- time graph with constant negative velocity.(i.e the object is moving towards the observer)



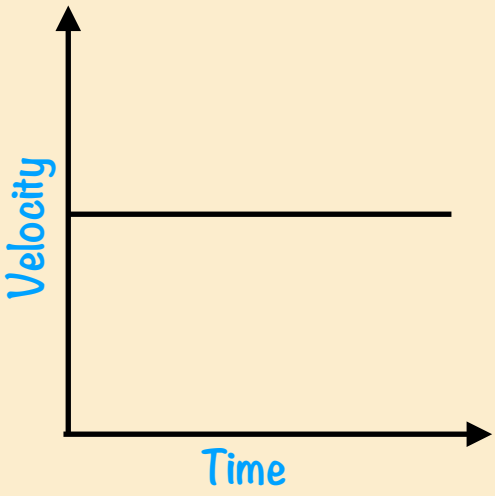
Displacement- time graph with increasing velocity.



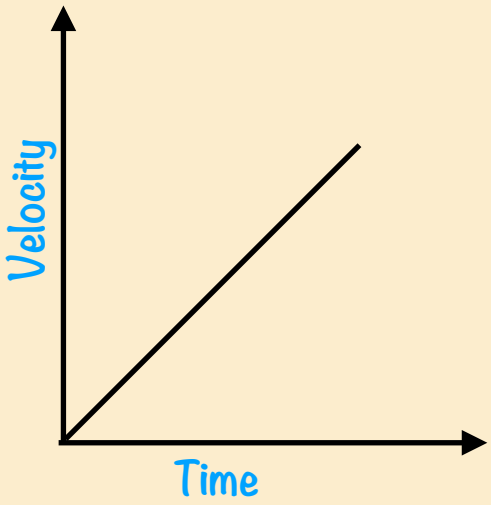
Displacement- time graph with decreasing velocity.

Velocity-Time graph:

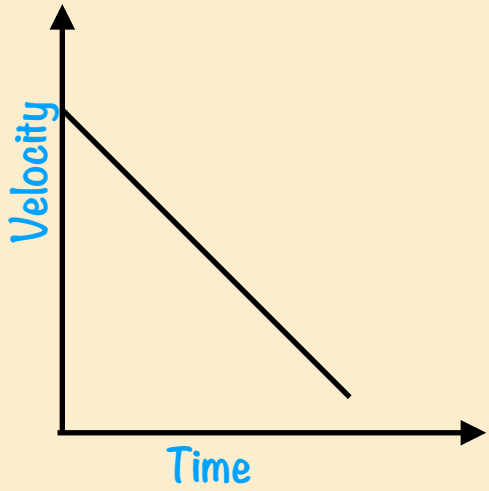
- Slope equals acceleration.
- The y- intercept equals the initial velocity.
- A straight line represents a constant acceleration.
- A curve line represents non uniform acceleration.
- The area under the curve equals the change in displacement.



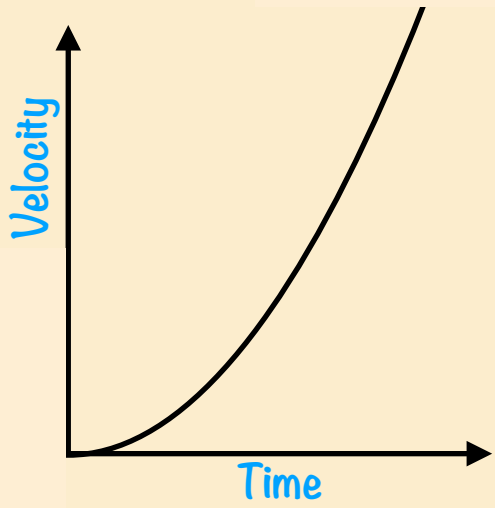
Velocity-time graph with constant velocity.
(i.e zero acceleration)



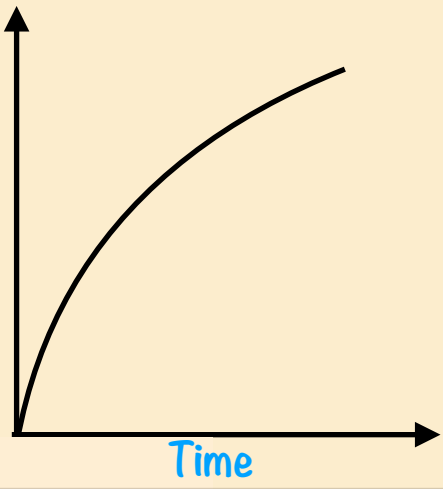
Velocity-time graph with increasing velocity.
(i.e constant positive acceleration)



Velocity-time graph with decreasing velocity.
(i.e constant negative acceleration)



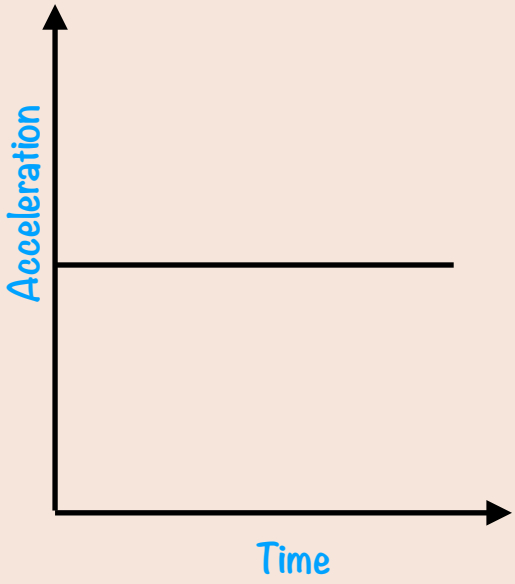
Velocity-time graph with increasing acceleration.



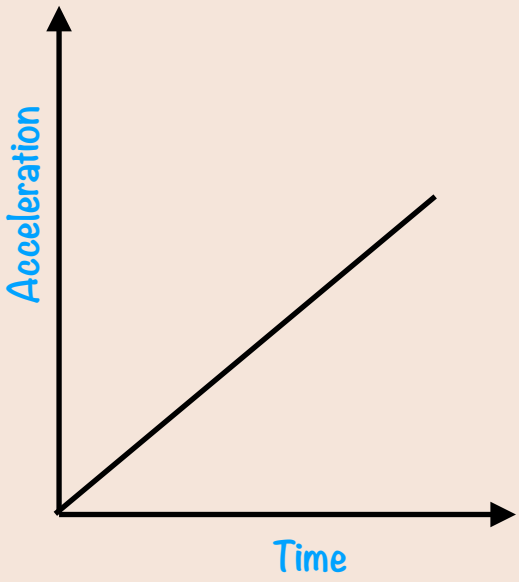
Velocity-time graph with decreasing acceleration.

Acceleration-Time graph:

- The y- intercept equals the initial acceleration.
- A zero slope (horizontal line) represents an object underging constant acceleration.
- The area under the curve equals the change in velocity.



Acceleration-time graph with constant acceleration.



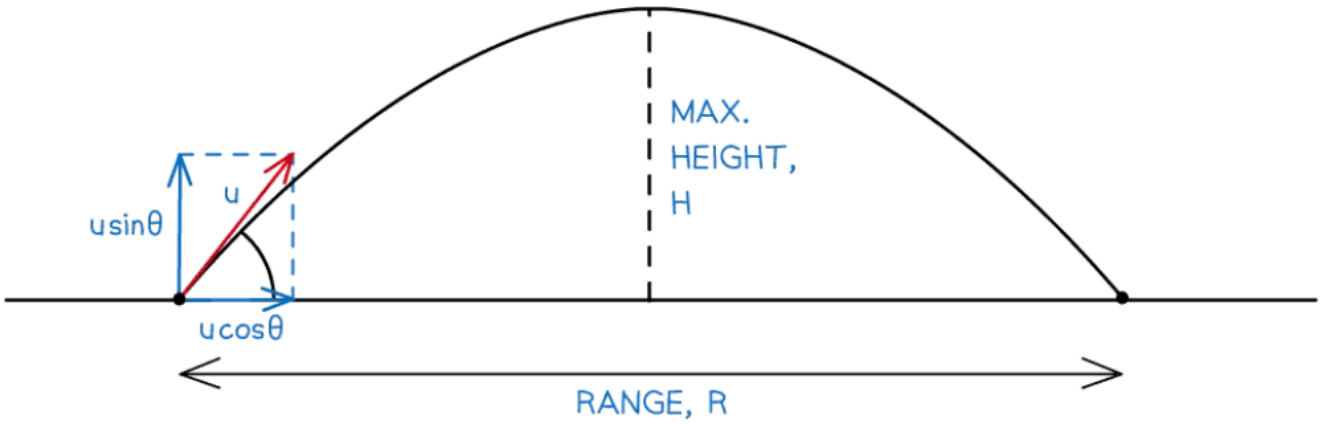
Acceleration-time graph with increasing acceleration.

Projectile Motion

Projectile motion: uniform velocity in one direction and constant acceleration in perpendicular direction.

- The trajectory of an object undergoing projectile motion consists of a **vertical** component and **horizontal** component. And this should be evaluated saperately.

- **Some terms and calculation used in projectile motion:**
  - **Time of flight:** how long the projectile is in the air.
  - **Maximum height attained:** the height at which the projectile is momentarily at rest.
  - **Range:** the horizontal distance travelled by the projectile.



Time of flight:

Considering vertical motion,

$u = usin\theta,\ \ a = -g,\ \ v = 0$

$v = u + at$

$0 = usin\theta - gt$

$\therefore t = \frac{usin\theta}{g}$

If the time to reach maximum height is t,

Then time of flight is 2t.

so, ttime of flight = $2t = \frac{2usin\theta}{g}$.

Maximum height:

Considering vertical motion,

$u = usin\theta,\ \ a = -g,\ \ v = 0$

$v^2 = u^2 + 2as$

$0 = (usin\theta)^2 - 2gH$

$\therefore H = \frac{(usin\theta)^2}{2g}$

so the maximum height attained is $\frac{(usin\theta)^2}{2g}$.

Range:

Considering vertical motion,

$u = ucos\theta,\ \ a = o,\ \ t = \frac{2usin\theta}{g}$

range = $velocity \times time = ucos\theta \times \frac{2usin\theta}{g}$

$= \frac{u^2 sin2\theta}{g}$.

so, the range of projectile motion is $\frac{u^2 sin2\theta}{g}$.