# MOTION IN A PLANE

## MOTION IN A PLANE WITH CONSTANT ACCELERATION

### Motion In A Plane

Introduction To Motion In Two Dimensions

We have learned about motion in a straight line and the three equations of motion. Now we will learn about motion in a plane. When we are talking about motion in a plane, we are talking about motion in two dimensions, since two dimensions make a plane. So we are taking two axes into consideration, generally X-axis and Y-axis. In order to derive equations of motion, we need to know about motion in one dimension.

### The Equations of Motion in a Straight Line Are:

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

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

Where,

- $v$ = final velocity of the particle
- $u$ = initial velocity of the particle
- $s$ = displacement of the particle
- $a$ = acceleration of the particle
- $t$ = time interval in which the particle is in consideration

In a plane, we have to apply the same equations separately in both the directions: Y axis and Y-axis.

**This would give us the equations for motion in a plane:**

$$v_y = u_y + a_y t$$

$$s_y = u_y t + \frac{1}{2} a_y t^2$$

$$v_y^2 = u_y^2 + 2a_y s$$

Where,

- $v_y$= final velocity of the particle in y direction
- $u_y$= initial velocity of the particle in y direction
- $s_y$= displacement of the particle in y direction
- $a_y$= acceleration of the particle in y direction
- t = time interval in which the particle is in consideration

**Similarly, for X-axis:**

$$V_x = u_x + a_x t$$

$$S_x = u_x t + \frac{1}{2} a_x t^2$$

$$V_x^2 = u_x^2 + 2a_x s$$

Where,

- $v_x$= final velocity of the particle in x direction
- $u_x$= initial velocity of the particle in x direction
- $s_x$= displacement of the particle in x direction
- $a_x$= acceleration of the particle in x direction
- t = time interval in which the particle is in consideration

**Relative Motion**

When we say the motion of body A relative to B we mean motion of A, as observed from B's frame of reference. Mathematically it is represented as:

$V_{BA} = V_B - V_A$

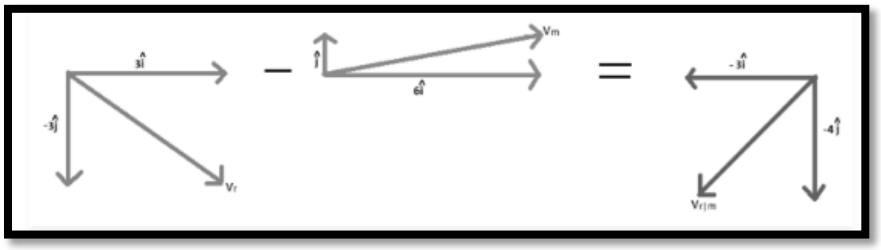
Where,

- $V_{BA}$ = Velocity of B as observed from A.
- $V_B$ = Velocity of B from the earth as the reference frame.
- $V_A$ = Velocity of A from the earth as the reference frame.

Consider a man running uphill while it is raining. It is difficult to decide from which side the man will get wet if we do not know the relative m of the man and rain with respect to each other. Suppose the components of velocity of man are given as 6i + j and that of rain is given by 3i – 3j. If we can find the angle at which the rain hits the man, we can easily decide from which direction the man gets hit by the rain. To find the relative velocity or relative motion of rain with respect to man, the velocity of a man with respect to rain must be subtracted, i.e.,

$$\vec{v}_{r|m} = \vec{v}_r - \vec{v}_m$$

Relative motion can be explained using the vector representation as:



It can be seen that with respect to the man, the rain is falling at an angle of

$$\tan^{-1}\left(\frac{3}{4}\right)$$

So, if the man is running in positive X- direction then rain must hit him from the front direction. So, if the man has to wear a bag, he must wear it on his back to prevent it from rain. Thus only by knowing the velocities, the direction of hitting of rain can be determined. Now, what happens if the horizontal component of the velocity of rain and man becomes equal? Interesting, isn't it? Well, in such a situation the rain will not hit the man from either side. So, to answer the question of whether one should run fast or slow in the rain to get less wet, it all depends on the velocities or relative motion.

## Projectile Motion

Projectile motion is one of the most common examples of motion in a plane. In projectile motion, the only acceleration acting is in the vertical direction, which is acceleration due to gravity (g). Therefore, equations of motion can be applied separately in X-axis and Y-axis to find the unknown parameters.