**Motion**

**2.1 Particle Motion**

The Position of a particle is specified by the value of each spatial coordinate, namely the x,y,z in the Cartesian.

The Motion of a Particle is defined by its position at every time t.

This means that we can see the three spatial coordinates as functions of time t

x = x(t)

y = y(t)

z = z(t)

Position can also be thought as a vector (tensor-3D-Vector)

Whose components are the above functions of time.

The path, or **trajectory**, of a particle is specified by that vector.

Classical Mechanics tries to predict from an initial condition and some dynamical law!

Very important is the role of **velocity**.

Velocity is thought as a vector.

In an infinitesimal displacement of the particle between time t and t+Δt

We say that

Becomes

Generally if you know calculus,

Velocity **v**  is defined as the first time-derivative of position.

In English, that means the rate of change of position with respect to time.

The unit of v is 1 m/s.

Instead of writing all these separate equations and x,y,z , we generally denote the coordinates as xi

Which translates to

Since velocity is a vector, it also has a magnitude defined as

This represents how fast the particle moves, without any specific direction. That Magnitude is called **Speed**.

**Acceleration** is the quantity that describes how quickly velocity changes over time.

If an object travels with a uniform/constant velocity, it experiences no acceleration.

(Later on, in Special Relativity you will learn that the reference frame of an observer that travels with uniform velocity is called IRF, which is short for Inertial Reference Frame. )

A constant velocity implies a constant speed and direction.

You might have guessed it by now, but

Acceleration is the first time derivative of velocity, or the rate of change of velocity with respect to time, or the second time derivative of position, since velocity is its first.

**2.3 Examples of Motion**

Lets say you have a closed system with a single particle in it.

Say that the particle starts to move at t=0 according to:

x(t) = 0

y(t) = 0

The Particle has no motion on the x-y axes but moves along the z-axis.

The constant z(0) and v(0), represent the initial of the position and velocity along the z direction at t=0. We also consider g to be a constant.

So the equations for the velocity are:

The z component with a little help of easy calculus can be rewritten as :

If you don’t understand this, or why the constants z(0) and v(0) were eliminated, I could not suggest you more to visit the Khan academy Calculus playlist on YouTube to learn the needed math. You can access it faster by visiting the math needed sections on the physics page of my site‼‼

Since the x and y components of velocity are 0 at all times, the z component velocity that starts out at t =0 is equal to the whole velocity vector. So, v(0) is the initial condition for velocity.

(Since x(0) = 0, y(0) = 0,z(0) = 0, t =0 so 1/2gt2=0)

As time passes, the -gt term becomes non-zero and it will overtake the initial value of velocity, so the particle will be moving along the negative z direction.

Then to Calculate the acceleration, we simple take the time derivative of -gt:

The acceleration along the z axis is constant and negative!