# Special Theory of Relativity (Einstein, 1905)

For B.Sc (H) Physics Students

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# These slides cover only concept of Frame of Reference and Galilean Transformation

Note:

If anyone have any query and doubt contact me on my mail id or phone number. I will provide you all 4-5 slides per day regarding these course for your better understanding.

Reference Book: Classical Mechanics (J.C. Upadhyaya)

Introduction to Special Relativity (Robert Resnick)

## Frame of Reference:

*A frame of reference is a set of coordinates that can be used to determine positions and velocities of objects in that frame. There are two types of frames.*

*(I) Inertial Frame of Reference (Follow law of Inertia, not accelerating relative to each other)*

*(II) Non-Inertial Frame of Reference (Accelerating, rotating frame of reference etc.)*

*???Read Different Co-ordinate systems and their conversion ….*

*(Such as Spherical, cylindrical, etc*

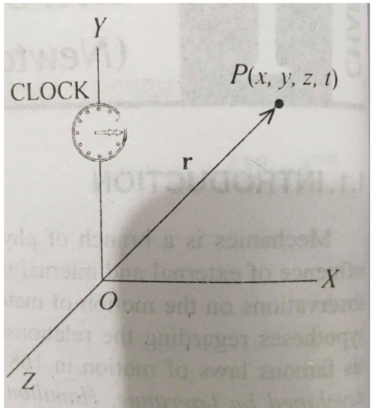

Fig. 1.1. Frame of reference

## *Event:*

*An event is something that occurs at a localized region in space over a localized interval in time, or, in an idealized limit, at a point in space at an instant in time. Thus, the motion of a particle through space could be thought of as a continous series of events, while the collision of two particles would be an isolated event, and so on.*

***Newton's Law of Motion: (Do Yourself)***

***Q. Prove that all those frame of reference moving with constant velocity realtive to an inertial frame, are also inertial.***

# The Galilean Transformation

*To derive these transformation equations, consider an inertial frame of reference S and a second reference frame S' moving with a velocity $v_x$ relative to S .*

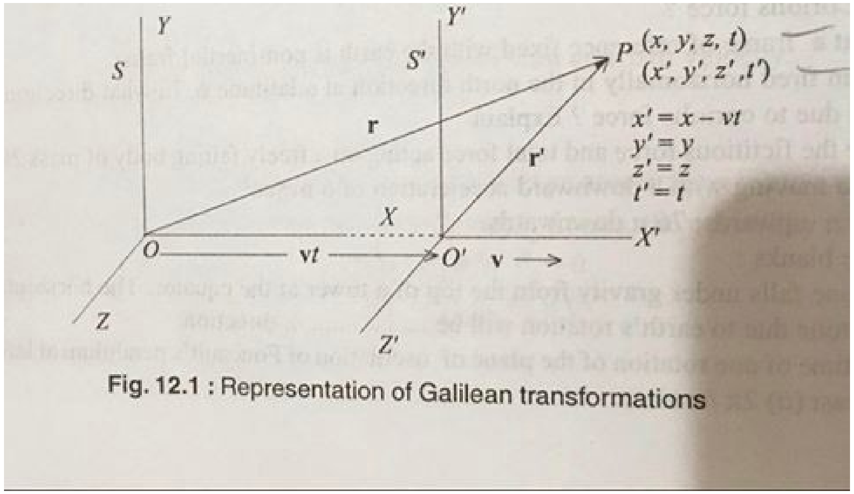

Fig. 12.1 : Representation of Galilean transformations

At ant time position vectors of a particle in the two frames are related by the equation

**r'= r – vt**

In the component form, the co ordinates are related by the equation

X' = x – vt; y'=y; z'=z

**These are referred as Galilean transformation.**

**x=x'-vt'; y=y'; z=z'; t=t' are known as inverse Galilean Transformation.**

**Q.2** Show that length or distance between two points is invariant under Galilean Transformation?

Differentiating above equation with respect to time we get,

$$\frac{d\mathbf{r}}{dt} = \mathbf{v} + \frac{d\mathbf{r}'}{dt} = \mathbf{v} + \frac{d\mathbf{r}'}{dt'} \qquad [\because t = t']$$

or $$\mathbf{u} = \mathbf{v} + \mathbf{u}' \qquad ...(5)$$

where $\mathbf{u}$ and $\mathbf{u}'$ are the observed velocities in $S$ and $S'$ frames respectively.

Eq. (5) transforms the velocity of a particle from one frame to another and is known as ***Galilean*** (or ***classical***) ***law of addition of velocities.***

Again differentiating eq. (5) with respect to time $t$, we have

$$\frac{d\mathbf{u}}{dt} = 0 + \frac{d\mathbf{u}'}{dt} = \frac{d\mathbf{u}'}{dt'} \qquad [\because t = t']$$

or $$\mathbf{a} = \mathbf{a}' \qquad ...(6)$$

Hence *according to Galilean transformations, the accelerations of a particle relative to S and S' frames are equal.*

It is to be mentioned that the Galilean transformations are based basically on two assumptions :

So, Galilean transformations are based on two assumptions;

*(I) There exists a universal time t which is the same in all reference system.*

*(II) The distance between two points in various inertial systems is the same.*