B.Sc. Part I

Paper I

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light, This variation becomes... larger. For example, when we consider the motion of sub-atomic particles inside the atom itself, the variation is considerable large.

Galilean Transformation :-

A particle in space can be located from the knowledge of its coordinates with reference to a particular frame of reference. These coordinates will be different in different frames of reference.

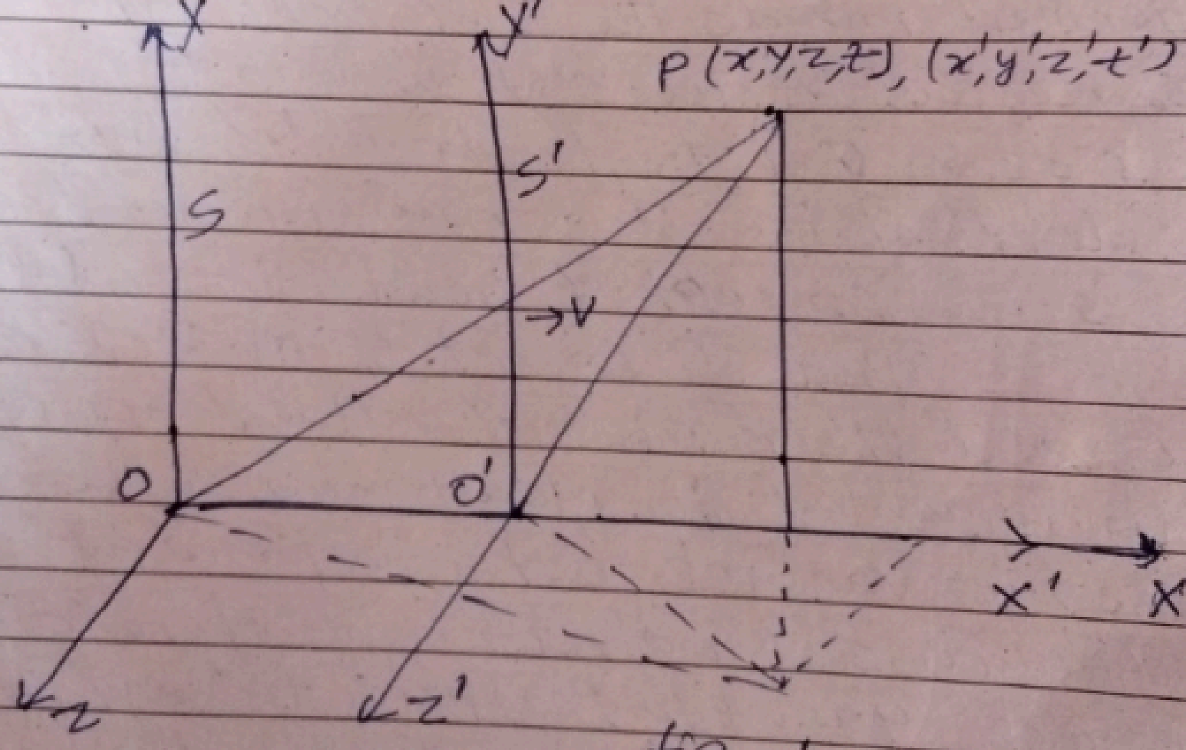

fig-1

Sometimes it is necessary to transform the coordinates from one reference frame to the other.

This transformation of coordinates of a particle from one inertial frame of reference to another inertial frame of reference is called the 'Newtonian-Galilean transformation' or 'Simply Galilean transformation".

To detect the position of a particle at a certain time, we should represent it in both space and time. Such a thing is called an event and may be represented by (x, y, z, t). Now let us consider a fixed frame of reference S(axes, OX, OY, OZ) and let an event P be represented as (x, y, z, t) in such a frame of reference. Let an observer sees the same event while he is in relative motion with a speed v along X-axis and let the origin O' at the time $t = t' = 0$ be at O. Then an observer in the moving frame $S'(OX', OY', OZ')$ observes the same event at time t' hence its coordinates may be represented as (x', y', z', t') in the frame S'. Now we have to find how the measurements x, y, z, t are related to x', y', z', t' as shown in fig-1.

Galilean transformation obviously connects the measurements in the frame S' with those in the frame S according to the equations.

$$x' = x - vt, \quad y' = y, \quad z' = z \text{ and } t' = t \quad \text{—— (1)}$$

The same can be expressed in frame S with those in frame S' by considering that S is moving with a velocity $-v$ w.r.t S'.

$\therefore x = x' + vt, \quad y = y', \quad z = z'$ and $t = t'$ — (2)

These two sets of equations are called Galilean transformation. by using these equations, the results observed in one reference frame can be transformed into the other reference frame.

Transformation of velocity :-

To convert velocity components measured in the frame S to their equivalents in S' frame, we differentiate, these equns and remembering that

$t' = t$ and $dt' = dt$, we get

$$\left.\begin{aligned} V_x' &= \frac{dx'}{dt'} = \frac{dx}{dt} - v = V_x - v \\ V_y' &= \frac{dy'}{dt'} = \frac{dy}{dt} = V_y \\ V_z' &= \frac{dz'}{dt'} = \frac{dz}{dt} = V_z \end{aligned}\right\} \quad \text{— (3)}$$

For conversion of acceleration the above components are differentiated again as

$$\left.\begin{aligned} a'_x &= \frac{d^2x'}{dt'^2} = \frac{d^2x}{dt^2} = a_x \\ a'_y &= \frac{d^2y'}{dt'^2} = \frac{d^2y}{dt^2} = a_y \\ \text{and} \quad a'_z &= \frac{d^2z'}{dt'^2} = \frac{d^2z}{dt^2} = a_z \end{aligned}\right\} \quad \text{--- (4)}$$

It follows That acceleration of a body is The Same in both The frames and hence Newton's second law of motion ($F = ma$) is equally Valid in both The frames. Thus we see That Newton's law of motion are invariant under Lorentz transformation in all inertial frames.