B. Sc. Part I
Physics Hons

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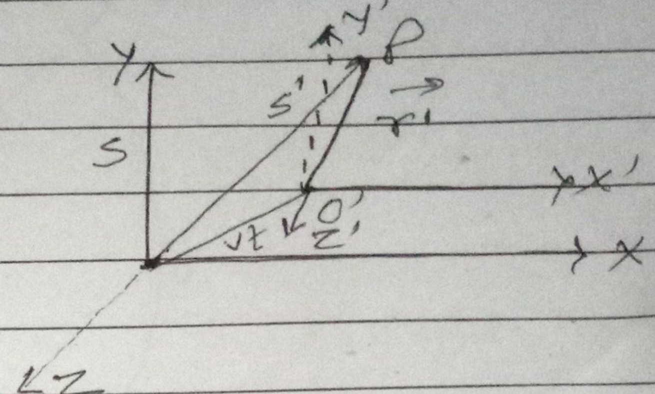
Relativity

Galilean Transformation in vector form

Consider two system S and S' moving with vector $\vec{v}$ to S. Initially origins of two systems coincide.



Let $\vec{r}$ and $\vec{r}'$ be the position vectors of any particle (event) P relative to origins O and O' of system S and S' respectively after time t.

Then from fig. using the law of triangle of vector addition

$$\vec{r} = \vec{r}' + \vec{v}t$$

or

$$\vec{r}' = \vec{r} - \vec{v}t \quad \text{—— (3)}$$

Also

$$t' = t \quad \text{—— (4)}$$

These equ^ns represent Galilean transformations of space and time in vector form.

equ^n (1), (2) & (3) are called time-dependent Galilean transformations, since they are time dependent and were obtained by Galileo.

Problem-1

Prove That the Galilean transformation of a position vector is expressed as $\vec{r} = \vec{r}_0 + \vec{r}' + \vec{v}t$. where $\vec{v}$ is the linear velocity of the frame O' and $\vec{r}_0$ is the position vector of origin O' as measured by O' and $t' = 0$.

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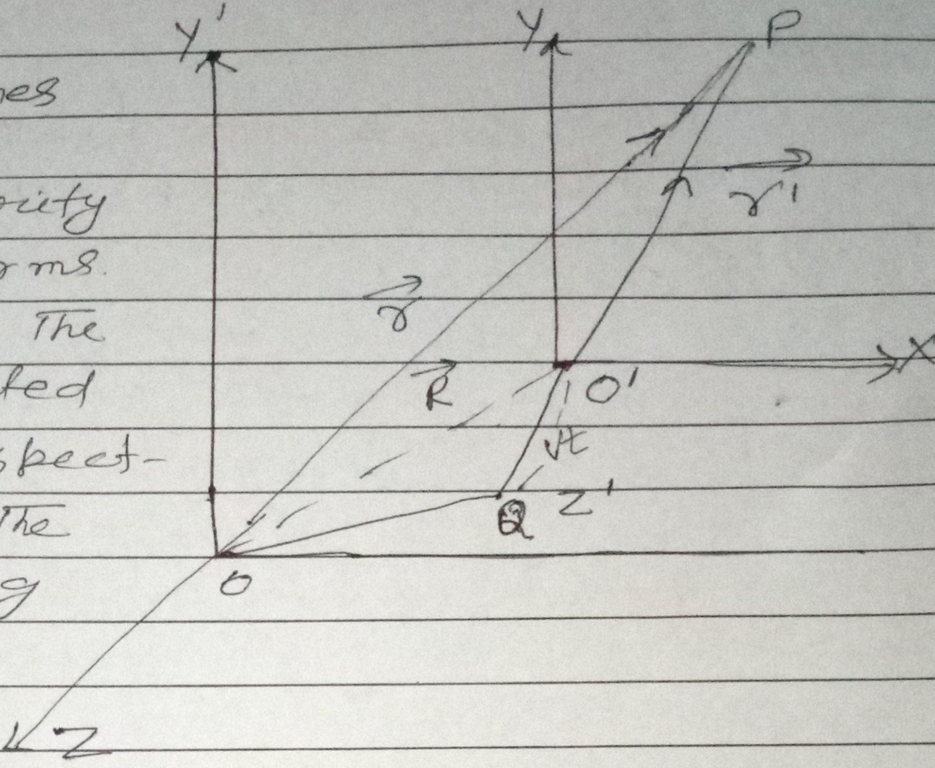
Consider two frames S & S' The latter moving with velocity $\vec{v}$ relative to form S. Let O and O' be the observers situated in S and S' respectively observing the event happening at P.



If $\vec{r}$ and $\vec{r'}$ are the position vector of the point P at any constant.

Then we have from fig

$$\vec{r} = r' + \vec{R} \qquad \text{—} \; (1)$$

where $\vec{R}$ is the position to O after time t.

If $\vec{r_0} = \vec{OQ}$ is the position vector of the observer O' relative to O at $t = 0$

Then from above fig

$$\vec{R} = \vec{OQ} + \vec{QO'} = \vec{r_0} + \vec{vt} \qquad \text{—} \; (2)$$

Since the distance traversed ($\vec{QO'}$) by the observer O' in time t is $\vec{vt}$ where $\vec{v}$ is the velocity of the O' relative to O.

Putting the value of $\vec{R}$ from (2) in (1)

we get
$$\vec{r} = \vec{r_1} + \vec{r_0} + \vec{vt}$$
$$\vec{r} = \vec{r_0} + \vec{r'} + \vec{vt'} \qquad (3)$$

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we get

$$\vec{r} = \vec{r'} + \vec{r_0} + \vec{Vt}$$

$$\vec{r} = \vec{r_0} + \vec{r'} + \vec{Vt'} \quad \text{--- (3)}$$

~~Proble~~

Problem 2 - Consider two system S & S', S' moving with velocity $\vec{V} = \vec{i} V_x + \vec{j} V_y + \vec{k} V_z$ relative to S. If the origins of the two systems coincide at $t = t' = t_0$ find the Galilean transformation equations.

Soln: The system S' is moving relative to S with velocities V_x, V_y & V_z along +ve directions of x, y and z axes respectively

If the origins of two frames coincide at

$t = t' = t_0$ Then

The distance traversed by observer O' in S' relative to observer O in S at any instant t along axis of

$$x = V_x (t - t_0)$$

The distance traversed by O' relative to O at any instant t along axis of $y = V_y (t - t_0)$

The distance traversed by O' relative to O at any instant

along z axis $= V_z (t - t_0)$

Thus the Galilean transformation equ^{n}s are given by

$$x' = x - V_x (t - t_0)$$

$$y' = y - V_y (t - t_0)$$

$$z' = z - V_z (t - t_0)$$

Proved