Special theory of relativity

In 1905 Einstein showed how measurements of time and space are affected by motion b/w an observer and what is being observed.

All motion is relative, the speed of light in free space is the same for all observers.

Frame of reference:- When we say that something is moving, what we mean is that its position relative to something else is changing.

An inertial frame of reference is one in which Newton's first law of motion holds. In such a frame, an object at rest remains at rest and an object in motion continues to move at constant velocity if no force acts on it.

Any frame of reference that moves at const. velocity relative to an inertial frame is itself an inertial frame.

The theory of relativity deals with the consequences of the lack of a universal frame of reference. Special relativity treats problems that involve inertial frames of reference. General relativity, treats problems that involve frames of reference accelerated with respect to one another.

Two Postulates of Special Relativity:-

The first, the principle of relativity, states:

the laws of physics are the same in all inertial frames of reference. This postulate follows from the absence of a universal frame of reference.

II^nd postulate is based on the results of many experiments:

The speed of light in free space has the same value in all inertial frames of reference. This speed is 2.998 × 10^8 m/s to four significant figures.

Galilean Transformation:-

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Suppose we are in an inertial frame of reference S and find the co-ordinates of some event that occurs at the time t are x, y, z. An observer located in a different inertial frame S′ which is moving with respect to S at the constant velocity v will find that the same event occurs at the time t′ and has the co-ordinates x′, y′, z′.

Galilean Transformation:

Before special relativity, transforming measurements from one inertial system to another seemed obvious. If clocks in both systems are started when the origins of S and S′ coincide, measurements in the x-direction made in

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S will be greater than those made in S′ by the amount vt, which is the distance S′ has moved in the x direction. That is,

$$x' = x - vt \quad \text{——— (1)}$$

There is no relative motion in the y and z directions, and so

$$y' = y \quad \text{——— (2)}$$

$$z' = z \quad \text{——— (3)}$$

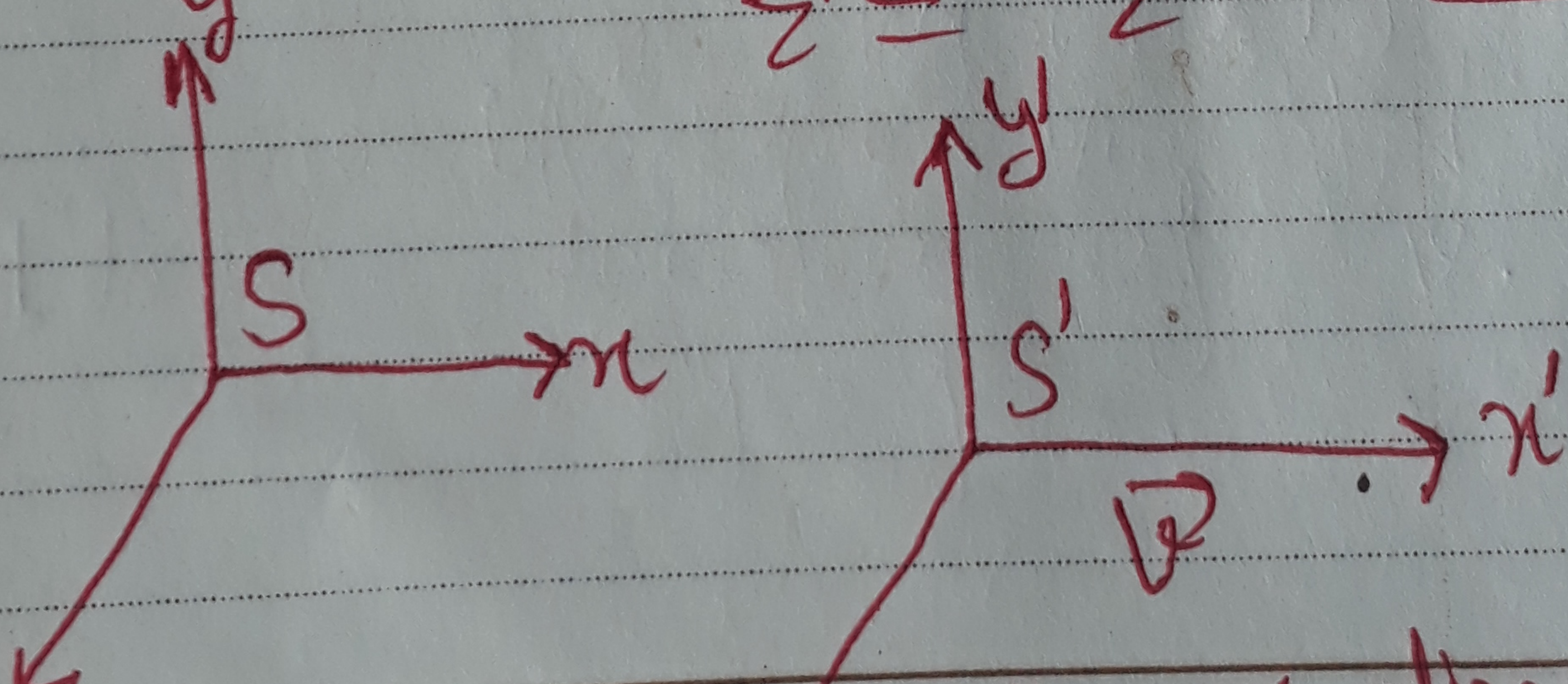

Fig: Frame S′ moves in the +x direction with the v relative to frame S.

In the absence of any indication to the contrary in our everyday experience, we further assume that,

$$t' = t \quad \text{——— (4)}$$

The set of eq^n (1) to (4) is known as the galilean transformation.

To convert velocity components measured in the S frame to their equivalents in the S' frame according to the galilean transformation, we simply differentiate x', y' and z' w.r.t. to time:

$$v'_x = \frac{dx'}{dt'} = v_x - v \quad \text{——— (5)}$$

$$v'_y = \frac{dy'}{dt'} = v_y \quad \text{——— (6)}$$

$$v'_z = \frac{dz'}{dt'} = v_z \quad \text{——— (7)}$$

G.T. and the corresponding velocity transformation violate both of the postulates of special relativity. The first postulate calls for the same eqs. of physics in both the S and S' inertial frames, but the eqs. of electricity and magnetism become very different when the G.T. is used to convert quantities measured in one frame into their equivalents in the other. The second postulate calls for the ~~same~~ same value of the speed of light c whether determined in S or S'. If we measure the ~~speed of light in~~ the x direction in the S system to be c, however, in the S' system it will be