Today's slides (6-8) deals with two topics;

---principle of relativity extended with the concept of the light and Maxwell's equation and

---second one is the most famous experiment Michelson-Morley Experiments.

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

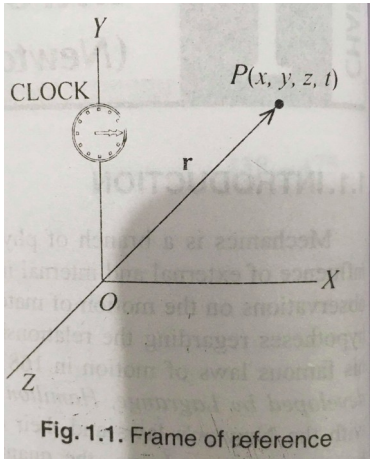


Fig. 1.1. Frame of reference

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 ɣ relative to S .

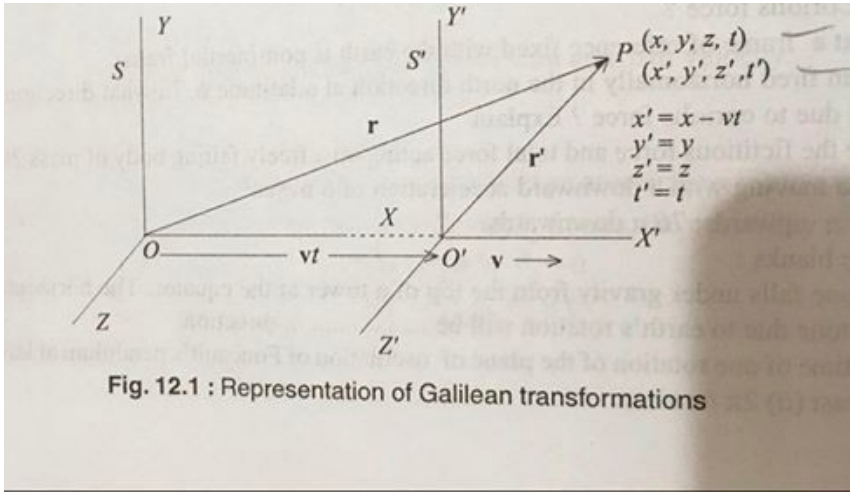


Fig. 12.1 : Representation of Galilean transformations

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

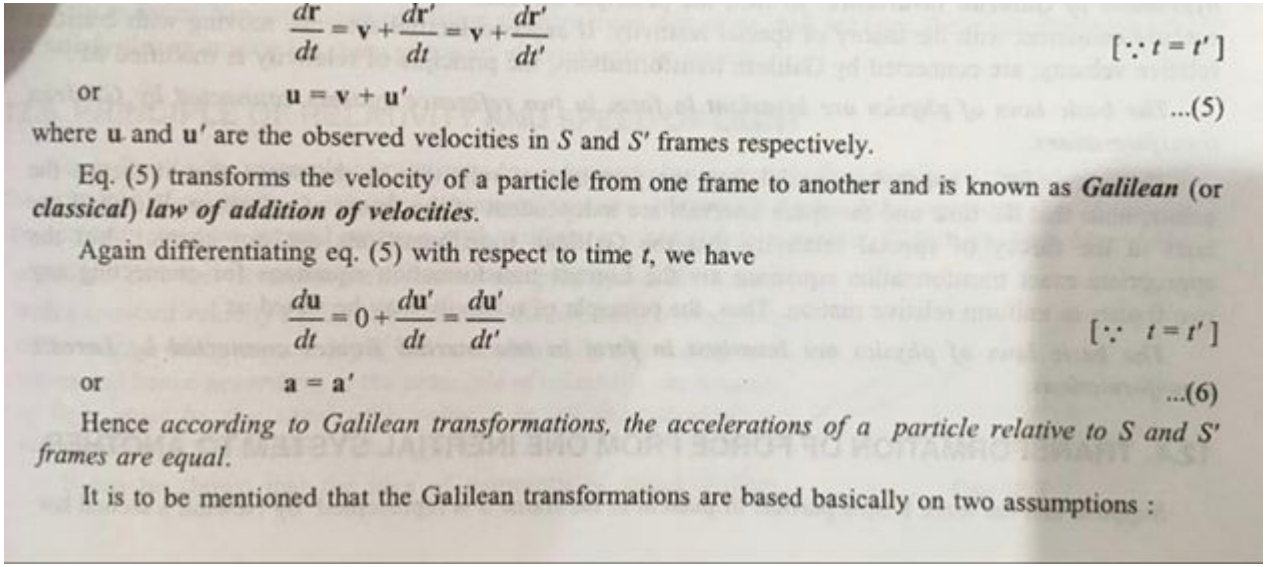
X’ = x – vt; y’=y; z’=z

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

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

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;

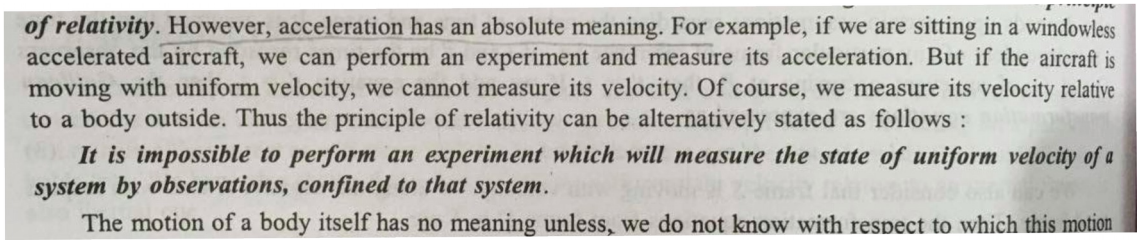
(I) There exists a universal time t which is the same in all reference system.

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

Principle of Relativity

Absolute velocity of a body has no meaning. It has meaning only when it is measured relative to some other body or frame of reference. If two bodies are moving with uniform relative velocity, it is impossible to decide which of them at rest or which of them is moving. This is known as principle of relativity.

Example:



of relativity. However, acceleration has an absolute meaning. For example, if we are sitting in a windowless accelerated aircraft, we can perform an experiment and measure its acceleration. But if the aircraft is moving with uniform velocity, we cannot measure its velocity. Of course, we measure its velocity relative to a body outside. Thus the principle of relativity can be alternatively stated as follows :

It is impossible to perform an experiment which will measure the state of uniform velocity of a system by observations, confined to that system.

The motion of a body itself has no meaning unless, we do not know with respect to which this motion

This principle is called Galilean or Newtonian principle of relativity and sometimes it is called hypothesis of Galilean invariance. The basic laws of physics are invariant in form of two reference systems connected by Galilean transformations.

Q. Show that Newton's Laws of motion are identical in all inertial frames of referenc OR Newtons laws of Motion are invariant under Galilean Transformation.

So why ?? need of Lorentz Transformation and Special Theory of Relativity???

Why Galilean Transformation are not correct???

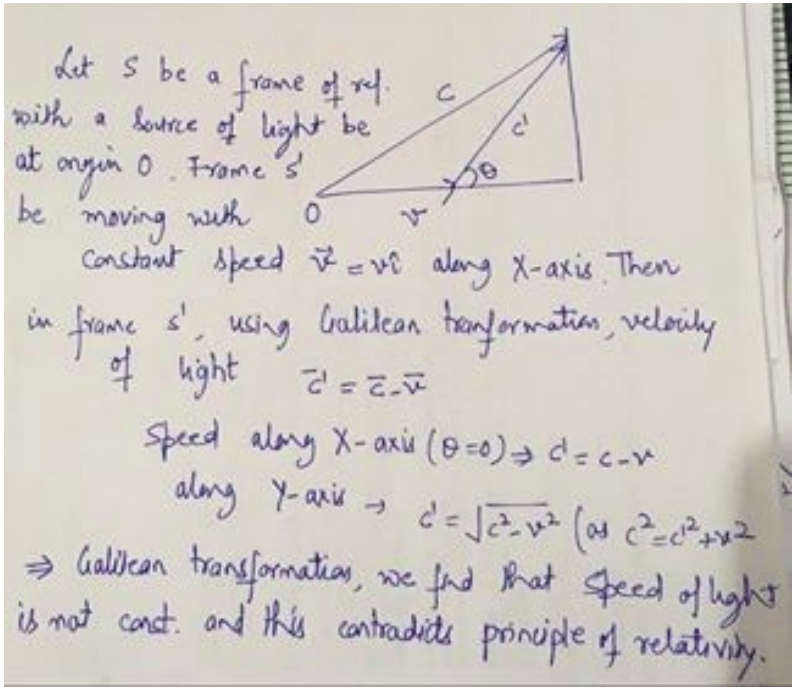
Note:

We see that Galilean transformations satisfy the principle of realtivity as for as Newton's law of motion are concerned, but as well as these transformation do not satisfy this principle for the propogation of electromagnetic waves.

Maxwell's Equations and the Ether

If the principle of relativity is extended to electrodynamics, Maxwell;s fundamental equations should remain the same in any two inertial systems with uniform constant relative motion. According to these equations, e.m. waves travels with speed of light in vacuum and light waves are basically e.m. waves. So, velocity of light must be same with the value of c in all inertial frames, independent of the motion of the light source.

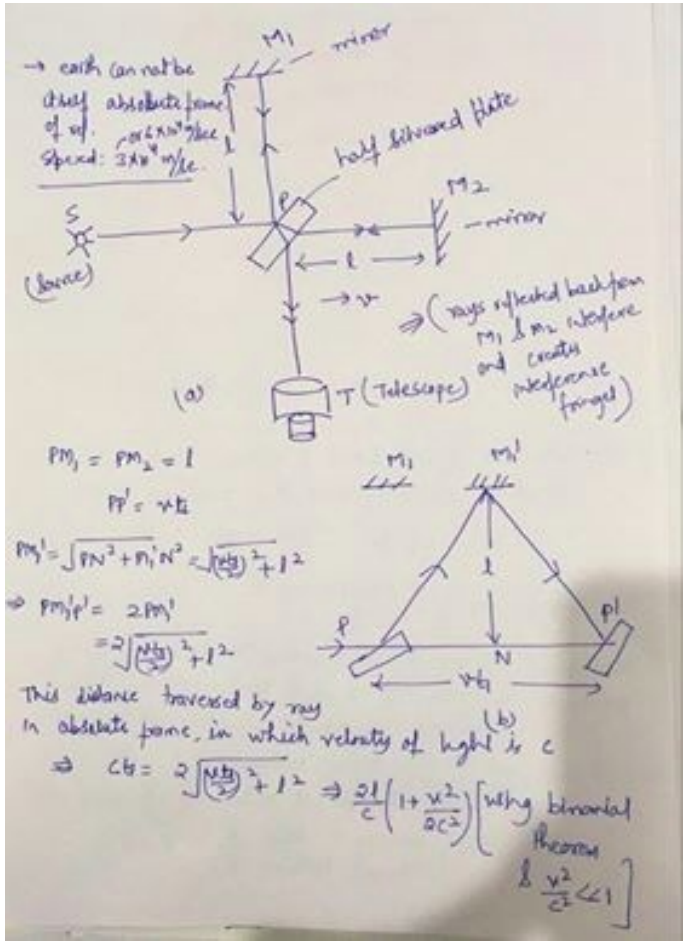
This can be shown as;

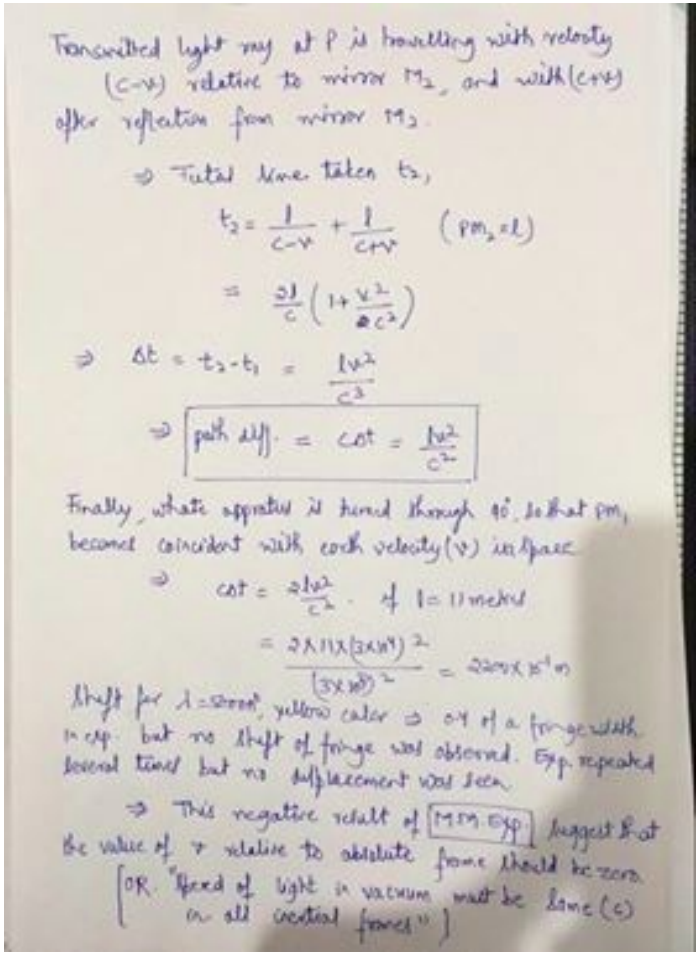


Note: This leads to the idean of an absolute motion and prefered or absolute frame in which speed of light is c and hence any other inertial fram, S' should be less suitable.

The Michelson-Morley Experiments

This experiment was designed to determine the motion of the earth relative to a frame of reference in which speed of the light is c in all direction. This frame is the previledge or absolute frame of reference.





Note: The negative result of this experiments suggests that the speed of light In vacuum must be same (c) in all inertial frames.