Prof. Vidya Sagar
Department of physics
B.Sc (Part-1) Hons.

Inertial frame and Non-inertial frame of referances.

The Surroundings of the moving body which are assumed to be at rest and relative to which the motion is discribe is Called a System or frame of reference.

The motion of the objects on the Surface of the earth is described relative to Some point on it. Thus earth is itself a frame of refrance. The other example of frame of refrance may be Considered to be the walls of the room, the position of Stars along the plumb line, the Sun etc. Newton introduced "absolute space" as Standard frame of reference.

There are generally two types of frame of reference System.

(i) The System relative to the body, not acted upon by an external force, is unaccelarated. This is also includes the State of rest.

(ii) The System relative to which the body, not acted upon by external force, is accelerated.

1. Inertial frames :— The frames relative to which the body, acted upon by an external force, is unaccelarated, are called 'Inertial frames'. In such frames, a body may be at rest or be moving with constant linear velocity.

Let us consider a co-ordinate system relative to which a body in motion has co-ordinates (x, y, z). If the body is not acted upon by an external force, then

$$m.\frac{d^2x}{dt^2} = 0, \quad m\frac{d^2y}{dt^2} = 0, \quad m\frac{d^2z}{dt^2} = 0$$

or $\frac{d^2x}{dt^2} = \frac{d^2y}{dt^2} = \frac{d^2z}{dt^2} = 0$, which gives

$$u_x = \frac{dx}{dt} = \text{Constant}$$

$$u_y = \frac{dy}{dt} = \text{Constant}$$

$$u_z = \frac{dz}{dt} = \text{Constant}$$

Here u_x, u_y and u_z are components of velocity u along x, y and z- directions respectively. Thus we may say that the application of an external force, a body in motion continues its motion with uniform velocity in a straight line which is Newton's first law of motion. Consequently we may say, "An inertial frame is one in which law of inertia or Newton's first law is valid".

Scanned with CamScanner

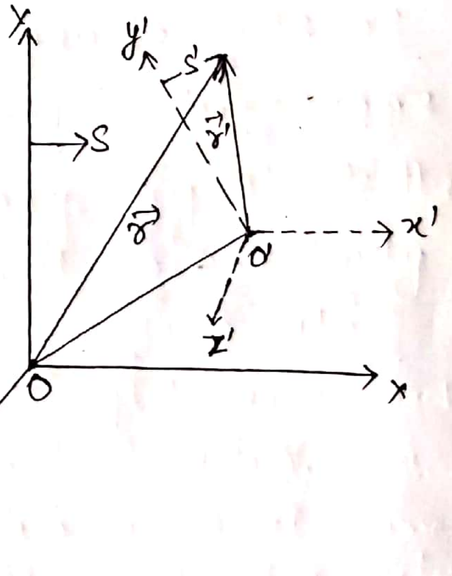
It is worthy to be mentioned that the concept of an inertial frame of reference is of real importance in physics for the following reasons.

(i) It is one of the basic assumptions of the special theory of relativity that the fundamental law of physics can all be so expressed as to assume the same mathema- tical ~~form~~ form in all inertial frames of reference.

(ii) It is in respect of such a frame of reference that all our fundamental laws of physics have been formulated.

(iii) It is provided with the property of being isotropic with respect to mechanical and optical experiments.

2. **Non-inertial frames:-** The frames relative to which the body, not acted upon by an external force is accelarted are Non-inertial frames.



Let us suppose that the frame S' is moving with a linear accleration $\vec{a}_0$ with respect to the inertial frame S. Then a particle at rest with respect to frame S will be clearly appear to be moving with an acceleration

$-\vec{a}_0$ with respect to frame s'. Therefore a particle having an accelartion $\vec{a}$ with respect to the inertial frame s will appear to have an accelartion.

$$\vec{a}' = \vec{a} - \vec{a}_0$$

$$\therefore \vec{F}' = m\vec{a}'$$
$$= m(\vec{a} - \vec{a}_0)$$

$$\vec{F} = m\vec{a} - m\vec{a}_0$$

where $m\vec{a} = \vec{F}$ is clearly the force acting on the particle in the inertial frame s.

$$\therefore \vec{F}' = \vec{F} - m\vec{a}_0$$
$$= \vec{F} - \vec{F}_0 \quad (\text{where } \vec{F}_0 = -m\vec{a}_0)$$

and, if $\vec{F} = 0$, $\vec{F}' = -\vec{F}_0$

Thus, even when no force is acting on the particle in frame s' which therefore a non-inertial frame.

This force $\vec{F}_0 = -m\vec{a}_0$ does not actually exist but appears to come into being purely in consequence of accelaration of fram s' with respect to s.