Lecture 1

1.1 Relativity:

Relativity means studying the fundamental physical laws and formulate them in different coordinate systems. In essence, physical quantities are first measured and formulated in a coordinate system. Second, trials are made to transform these measurements and formulations in another coordinate system in relative motion to the original coordinate system in which measurements have been taken. These coordinate systems are usually referred to as inertial frame of reference.

1.2 Inertial Frame of Reference:

A "frame of reference" is just a set of coordinates - something you use to measure physical dynamic quantities in Newtonian mechanical problems - like positions and velocities, so we also need a clock. A point in space is specified by its three coordinates (x,y,z) and an "event" like, say, a little explosion by a place and time - (x,y,z,t)

An inertial frame is defined as one in which Newton's law of inertia holds -- that is, any body which isn't being acted on by an outside force stays at rest if it is initially at rest, or continues to move at a constant velocity if that's what it was doing to begin with. An example of a non-inertial frame is a rotating frame, such as a carousel.

1.3 Physical Dynamic Quantities:

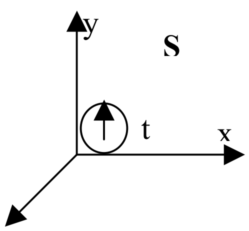
By physical dynamic quantities we mean measurable quantities, like position, velocity, momentum, energy and the like. An observer, in a different coordinate system, can only measure these quantities. In other words an observer can never detect his motion in his inertial frame of reference. So, two different frames are usually considered, one in which the observer reside in and one where the dynamic quantities are to be measured. These two different frames are in relative motion and bring about links between space and time, matter and energy, as well as electricity and magnetism.

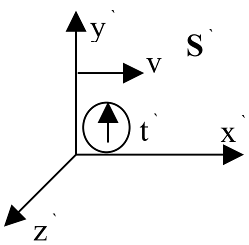
1.4 Gallilean Transformation:

Assume two inertial systems S and S` where S` proceeds relative to S at a speed v along the x-axis. For convenience, let us label the moment when O' passes O as the zero point of timekeeping. Now what are the coordinates of the event (x,y,z,t) in S'? It's easy to see t' = t -- we synchronized the clocks when O' passed O. Also, evidently, y' = y and z' = z, from the figure. We can also see that x = x' +vt. Thus (x,y,z,t) in S corresponds to (x',y',z', t') in S', where:

$$x' = x - vt$$
$$y' = y$$
$$z' = z$$
$$t' = t$$

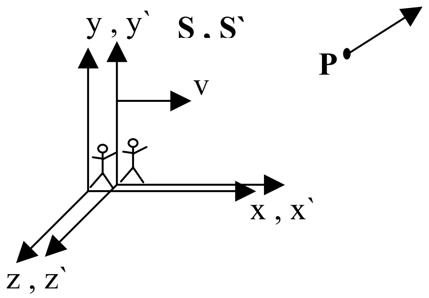
set of equations (1)

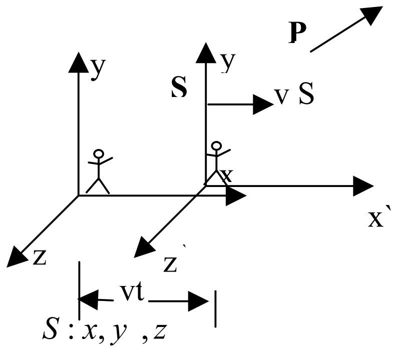




Assume now a particle **P** is to be monitored by the observers **O** in **S** and **O`** in **S`**. we need now to write down the position, velocity components and acceleration components of the particle in **S** and **S`**.

t = t`=0 t = t`>0





Position of P:

$S: x_o, y_o, z_o$ $S: x, y, z$

$S`: x'_0, y'_o, z'_o$ $S`: x', y', z'$

Velocity of P:

$S: \dot{x}_o, \dot{y}_o, \dot{z}_o$ $S: \dot{x}, \dot{y}, \dot{z}$

$S`: \dot{x}'_o, \dot{y}'_o, \dot{z}'_o$ $S`: \dot{x}', \dot{y}', \dot{z}'$

Acceleration:

$S: \ddot{x}_o, \ddot{y}_o, \ddot{z}_o$ $S: \ddot{x}, \ddot{y}, \ddot{z}$

$S`: \ddot{x}'_o, \ddot{y}'_o, \ddot{z}'_o$ $S`: \ddot{x}', \ddot{y}', \ddot{z}'$

The equations that transform from the unprimed coordinate system to the primed one are the set of equations (1). The first and the second time-derivatives of the equation (1) give the velocity and acceleration transformation equations:

Velocity Transformation:

$$\dot{x}' = \dot{x} - v$$
$$\dot{y}' = \dot{y}$$
$$\dot{z}' = \dot{z}$$

Acceleration Transformation:

$$\ddot{x}' = \ddot{x}$$
$$\ddot{y}' = \ddot{y}$$
$$\ddot{z}' = \ddot{z}$$

1.5 Conclusions:

1. Newton second law, ***Force = mass*** $\times$ ***acceleration,*** is invariant under Gallilean transformation.
2. An observer can not detect his motion within his inertial frame of reference by any dynamical experiment performed wholly within the moving frame.