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Subject — Physics.

Title of the Topic — Inertial and Noninertial frames of references.

Name of Program — B.Sc. (Physics Subsidiary)
Part - I
Paper - I (Group - B).

9.00

Frame of Reference — A system of coordinate axis which defines the position of a particle or an event in a two or 3D space is called a frame of reference.

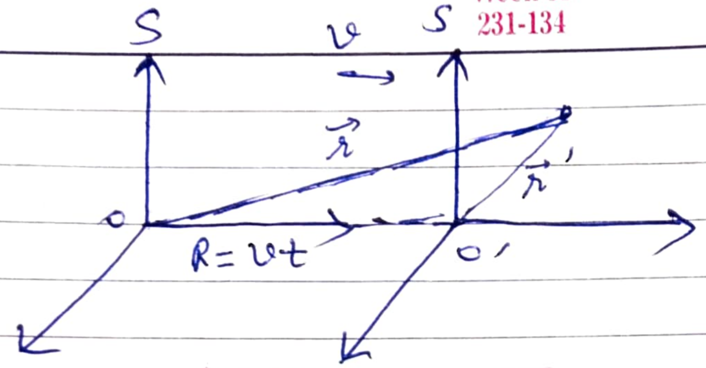
There exist basically two types of frame of ref.
① Inertial frame of ref.
② Non-Inertial " " ".

Newtonian or Galilean or Inertial frame of ref.

Newton's Ist law of motion is also known as law of inertia. A reference frame or a coordinate system in which Newton's Ist law of motion holds good is known as an inertial frame of reference.
i.e. In an inertial frame a body continues in its state of rest or of uniform motion in a straight line as long as no external force acts on it.
∴ All the frames of reference moving with a constant vel. w.r.t an inertial frame are also inertial frames of reference.

Consider an inertial frame of ref. S and another frame S' such that frame S' is free to have only translatory motion w.r.t S. Initially origins O & O' are coincident.
Let S' has moved a distance $OO' = R$ with vel v in time t ∴ $\vec{OO'} = R = \vec{v}t$.

∴ position vectors $\vec{r}$ & $\vec{r}'$ of a Particle P w.r.t S & S' are related as $\vec{r} = \vec{r}' + R$



$$\therefore \boxed{\vec{r} = R + \vec{r}'} \Rightarrow \vec{r}' = \vec{r} - \vec{R}$$

$$\Rightarrow \vec{r}' = \vec{r} - \vec{v}t$$

$$\Rightarrow \frac{d^2\vec{r}}{dt^2} = \frac{d^2\vec{r}'}{dt^2} \qquad \{\because \vec{v} = \text{constant}$$

$\Rightarrow$ acc^n of the particle is same in the two f.o.r.

$\Rightarrow$ if the particle be at rest in inertial frame S, it would also appear to be at rest in frame S'.

Hence all the f.o.r moving with constant vel. w.r.t inertial frame are also inertial f.o.r.

Non Inertial Frame of Ref.

A f.o.r. having an accelerated motion w.r.t an inertial frame are called non-inertial f.o.r. Since a uniformly rotating frame has a centripetal acc^n. It is also an inertial frame of ref.

$\therefore$ A non inertial frame is either a frame having uniform linear acc^n or a frame which is uniformly rotating

Earth :- A non inertial f.o.r, because apart from going round the sun, it also spins about its own axis, This imparts to a body in the f.o.r. located on earth, a centripetal acc^n $= \omega^2 R = \left(\frac{2\pi}{24\times60\times60}\right)^2 \times 6.4\times10^8 = 3.4$ cm/s^2, which ca be neglected and earth taken to be an inertial f.o.r 9.00

10.00

Galilean Transformation

11.00

Transformation Eqn. — Equations relating the two sets of coordinates of the event in the two 12.00 systems are called Transformation Eqn.

1.00

Galilean Trans. — And if the two systems happens to be inertial or Galilean ones, the 2.00 Transformation is referred to as a Galilean "

3.00

Let S & S' be two inertial f.o.r. with ~~observers~~ S at rest 4.00 and S' moving with uniform vel. v along +x dirn.

5.00

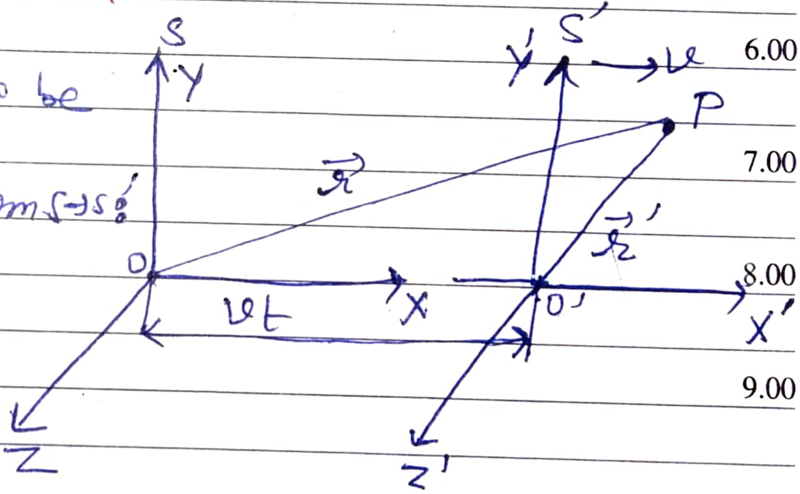
(a) Transformation of Position —

6.00

If we assume time t to be independent of any f.o.r.

7.00

∴ 4 Transformation eqn. from S→S':



8.00

$x' = x - vt$

$y' = y$

9.00

$z' = z$

$t' = t$

Inverse Transf. Eqn. (S'→S)

$x = x' + vt$

$y = y'$

$z = z'$

$t = t'$ ⟹ Time is invariant under Galilean Transformation

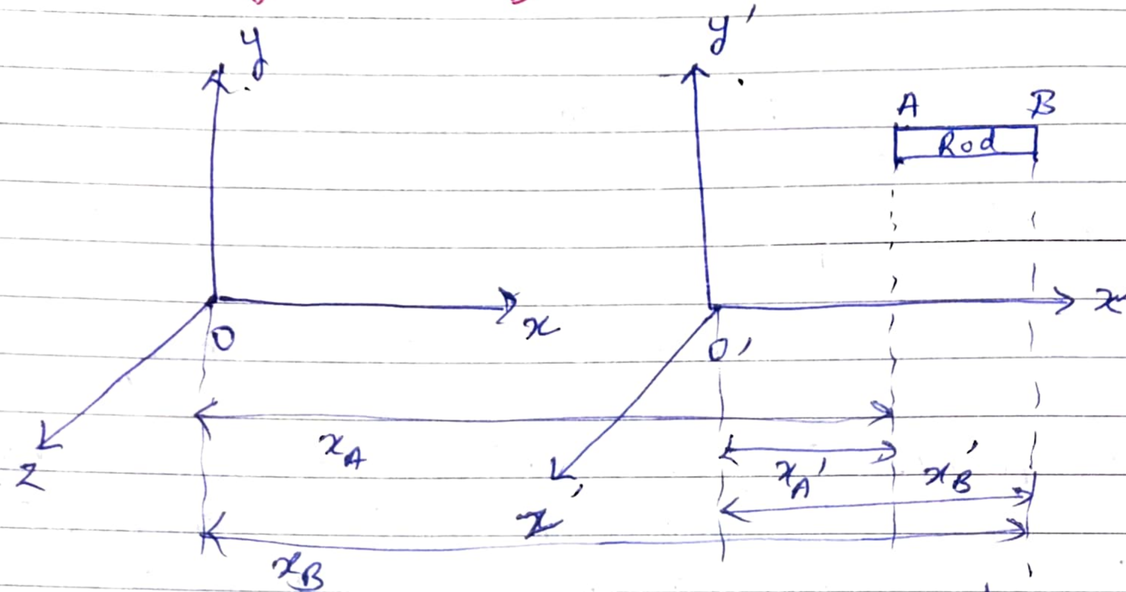
$x' = x - vt$

$y' = y$

$z' = z$

$t' = t$

9.00 (b) Transformation of distance of length.
10.00
11.00
12.00
1.00
2.00



3.00 S frame :- $L = x_B - x_A$
S' " :- $L' = x_B' - x_A'$.

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

4.00
$L' = x_B' - x_A'$
5.00
$L' = x_B - vt - (x_A - vt)$
$L' = x_B - x_A + 0$
6.00
$L' = L$

$\therefore$ length is invariant under Galilean Transformation
7.00
(c) Transformation of vel.
8.00 Let u_x & u_x' be the vel. of the particle in S & S' frame along x-dirn.
9.00

$$u_x = \frac{dx}{dt}, \quad u_x' = \frac{dx'}{dt}$$

$$u_y = \frac{dy}{dt}, \quad u_y' = \frac{dy'}{dt} = \frac{dy}{dt} = u_y$$

$$u_z = \frac{dz}{dt}, \quad u_z' = \frac{dz'}{dt} = \frac{dz}{dt} = u_z$$

$$u_x' = \frac{d}{dt}(x') = \frac{d}{dt}(x - vt)$$

$$= \frac{dx}{dt} - v = u_x - v$$

$\therefore$ $u_x' \neq u_x$. i.e. vel is not invariant under Galilean Transformation.

(d) Transformation of Acc^n :-

acc^n of Particle in S' $= a_x' = \frac{d^2x'}{dt^2} = \frac{du_x'}{dt}$

$$a_x' = \frac{d}{dt}[u_x - v]$$

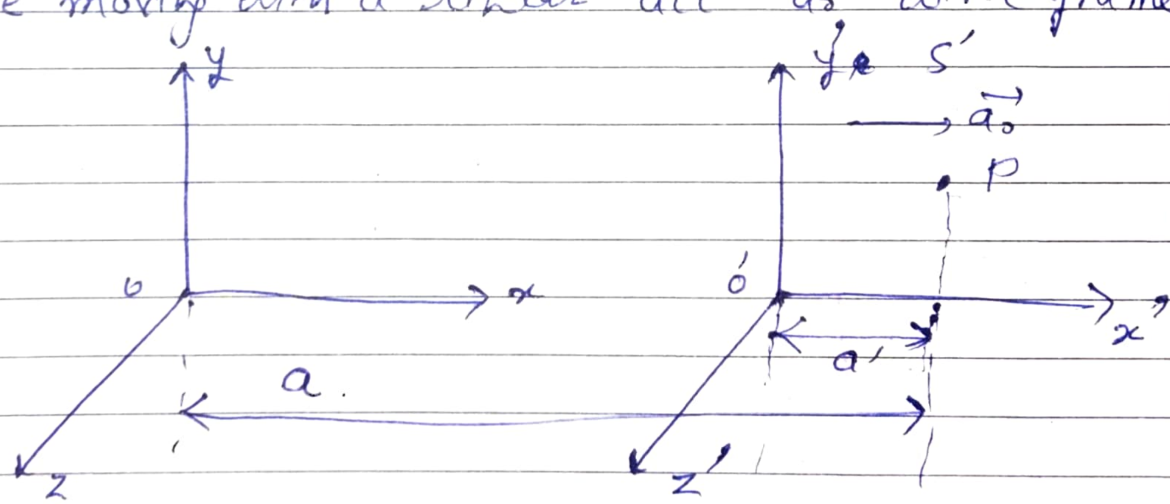
$$a_x' = a_x - 0$$

$$\Rightarrow a_x' = a_x$$

$\Rightarrow$ acc^n is invariant under Galilean Transformation.

Frames of reference with Linear Acc^n.

Let S' be moving with a linear acc^n $\vec{a_0}$ w.r.t frame S.



$\therefore$ acc^n of P w.r.t $S = \vec{a}$

acc^n of P w.r.t $S' = \vec{a}'$

$$\therefore \vec{a}' = \vec{a} - \vec{a_0}$$

multiplying both sides by m ——

$$m\vec{a}' = m\vec{a} - m\vec{a_0}$$

$$\vec{F}' = \vec{F} - m\vec{a_0}.$$

$$\vec{F}' = \vec{F} - \vec{F_0}$$ {Let $m\vec{a_0} = \vec{F_0}$

~~Let $\vec{F_0} =$~~

Let $\vec{F} = 0$ ie no force acts on the particle in frame S, but still a force $\vec{F_0} = m\vec{a_0}$ appears to be acting on the particle in frame S'. Which is therefore a noninertial frame. Relation $\vec{a}' = \vec{a} - \vec{a_0}$ is called Galilean law of composition of acc^n.

Classical Relativity — Galilean Invariance

Galilean Invariance — It clearly means that the fundamental physical laws and principles are all invariant to Galilean Transformation ie. the fundamental physical laws and principles are identical in all inertial frames of ref.

(1) Newton's law of motion.

Let $\vec{F} \rightarrow$ force acting on mass m in frame S
$\vec{F}' \rightarrow$ " " " " " " " S'

$$\therefore \vec{F} = m\vec{a} \quad \& \quad \vec{F}' = m\vec{a}'$$

$$\Rightarrow \boxed{\vec{F} = \vec{F}'} \quad \because \left[\vec{a} = \vec{a}' \text{ ie acc}^n \text{ is Variant} \right.$$

$\rightarrow$ Newton's law of motion is invariant to Galilean Transformation.

(ii) Law of conservation of mom. —

Consider 2 particles of masses m_1 & m_2 in frames, moving with vel $\vec{u}_1$ & $\vec{u}_2$ before collisions, and with $\vec{v}_1$ and $\vec{v}_2$ after the collision.

∴ From law of conservation of mom.

In S : $m_1\vec{u}_1 + m_2\vec{u}_2 = m_1\vec{v}_1 + m_2\vec{v}_2$ — (1)

In S' : $m_1\vec{u}_1' + m_2\vec{u}_2' = m_1\vec{v}_1' + m_2\vec{v}_2'$ — (2)

{ assume masses remain unaltered in 2 inertial frame

Since
$$\left.\begin{aligned} \vec{u}_1 &= \vec{u}_1' + v \\ \vec{u}_2 &= \vec{u}_2' + v \\ \vec{v}_1 &= \vec{v}_1' + v \\ \& \ \vec{v}_2 &= \vec{v}_2' + v. \end{aligned}\right\} \text{— (3)}$$

Putting (3) in (1)
$$m_1(\vec{u}_1' + v) + m_2(\vec{u}_2' + v) = m_1(\vec{v}_1' + \vec{v}) + m_2(\vec{v}_2' + \vec{v})$$

$$\Rightarrow m_1\vec{u}_1' + m_2\vec{u}_2' = m_1\vec{v}_1' + m_2\vec{v}_2'$$

⇒ Law of conservation of mom is invariant to Galilean Transf. ie it holds good in all inertial frames of ref.

Thus whereas momentum, by itself is not invariant to Galilean transformation, the principle of conservation of mom. is.

(iii) The law of conservation of Energy :-

According to conservation of Energy -

S frame : $\frac{1}{2}m_1\vec{u}_1^2 + \frac{1}{2}m_2\vec{u}_2^2 = \frac{1}{2}m_1\vec{v}_1^2 + \frac{1}{2}m_2\vec{v}_2^2 + E$ — (1)

∀ E → It is part of the energy of particles (before collision) appearing in some other forms like heat etc

9.00 In S' frame: $\frac{1}{2}m_1\vec{u}_1'^2 + \frac{1}{2}m_2\vec{u}_2'^2 = \frac{1}{2}m_1\vec{v}_1'^2 + \frac{1}{2}m_2\vec{v}_2'^2 + E$ — (2)

from (1) putting $\vec{u}_1$ & $\vec{u}_1$, $\vec{u}_2$ & $\vec{v}_2$

10.00 ~~$\Rightarrow \frac{1}{2}m_1(\vec{u}_1'+\vec{v})$~~

11.00 $\Rightarrow \frac{1}{2}m_1(\vec{u}_1'+\vec{v})^2 + \frac{1}{2}m_2(\vec{u}_2'+\vec{v})^2 = \frac{1}{2}m_1(\vec{v}_1'+\vec{v})^2 + \frac{1}{2}m_2(\vec{v}_2'+\vec{v})^2 + E$

12.00 $\Rightarrow \frac{1}{2}m_1\vec{u}_1'^2 + \frac{1}{2}m_2\vec{u}_2'^2 + \frac{1}{2}m_1\vec{v}^2 + \frac{1}{2}m_2\vec{v}^2 + \underbrace{m_1\vec{u}_1'\,\vec{v}}$

1.00 $\underbrace{+ m_2\vec{u}_2'\vec{v}} = \frac{1}{2}m_1\vec{v}_1'^2 + \frac{1}{2}m_1\vec{v}^2 + \underbrace{m_1(\vec{v}_1'\vec{v})} + \frac{1}{2}m_2\vec{v}_2'^2 + \frac{1}{2}m_2\vec{v}^2$

2.00 $+ \underbrace{m_2(\vec{v}_2'\vec{v})} + E$

3.00 since $m_1\vec{u}_1' + m_2\vec{u}_2' = m_1\vec{v}_1' + m_2\vec{v}_2'$

4.00 $\therefore \frac{1}{2}m_1\vec{u}_1'^2 + \frac{1}{2}m_2\vec{u}_2'^2 = \frac{1}{2}m_1\vec{v}_1'^2 + \frac{1}{2}m_2\vec{v}_2'^2 + E$

5.00 $\Rightarrow$ Law of Conservation of energy is invariant to Galilean Transformation.

6.00

7.00

Law of Conservation of momentum using Newton's Third law of motion.

8.00 Consider two particles having masses m_1, m_2 initial vel $\vec{u}_1$ and $\vec{u}_2$ and final vel. $\vec{v}_1$ & $\vec{v}_2$ respectively

9.00

$\therefore \vec{F}_{12} = \frac{m_1(\vec{v}_1 - \vec{u}_1)}{t_1}$ & $\vec{F}_{21} = \frac{m_2(\vec{v}_2 - \vec{u}_2)}{t_2}$

Let $t_1 = t_2 = t$

since $\vec{F}_{12} = -\vec{F}_{21}$

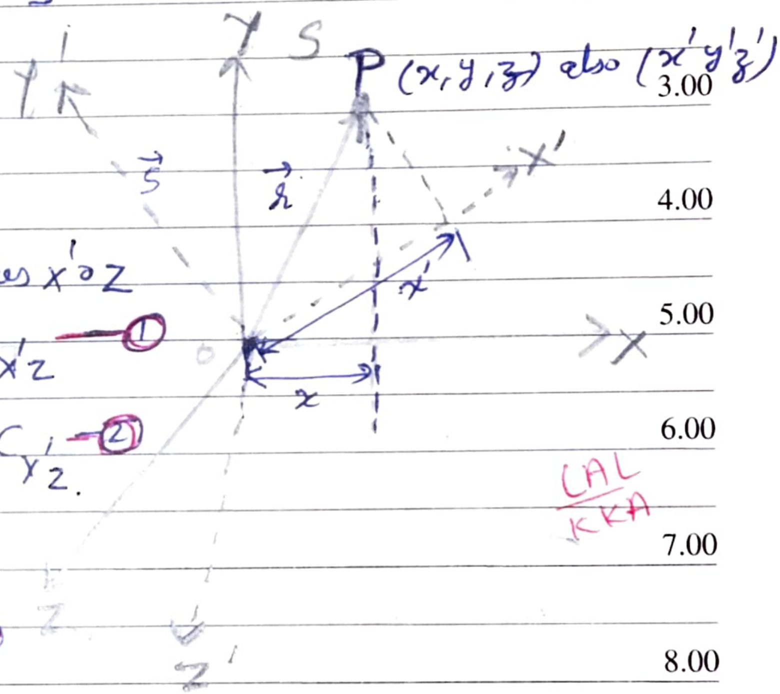
$\Rightarrow \frac{m_1(\vec{v}_1 - \vec{u}_1)}{t} = \frac{-m_2(\vec{v}_2 - \vec{u}_2)}{t}$

$$\Rightarrow m_1\vec{v_1} + m_2\vec{v_2} = m_1\vec{u_1} + m_2\vec{u_2}$$

which is law of conservation of linear momentum.

Transformation Eqn. for a frame of reference inclined to an inertial frame.

Let $S \rightarrow$ Inertial or a Galilean f.o.r and S' is f.o.r. with its origin coinciding with that of S, but with its coord. axes inclined to that of S



x' = Sum of components of x, y, z along the axis OX'.

$$= x\cos X'OX + y\cos X'OY + z\cos X'OZ$$

$$= x\,C_{XX'} + y\,C_{X'Y} + z\,C_{X'Z} \quad (1)$$

Similarly $$y' = x\,C_{Y'X} + y\,C_{Y'Y} + z\,C_{Y'Z} \quad (2)$$

& $$z' = x\,C_{Z'X} + y\,C_{Z'Y} + z\,C_{Z'Z} \quad (3)$$

$$\therefore \frac{dx'}{dt} = \frac{dx}{dt}C_{XX'} + \frac{dy}{dt}C_{X'Y} + \frac{dz}{dt}C_{X'Z}$$

$$\frac{dy'}{dt} = \frac{dx}{dx}C_{Y'X} + \frac{dy}{dt}C_{Y'Y} + \frac{dz}{dt}C_{Y'Z}$$

$$\frac{dz'}{dt} = \frac{dx}{dt}C_{Z'X} + \frac{dy}{dt}C_{Z'Y} + \frac{dz}{dt}C_{Z'Z}.$$

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9.00 $\therefore \frac{d^2x'}{dt^2} = \frac{d^2x}{dt^2} C_{x'x} + \frac{d^2y}{dt^2} C_{x'y} + \frac{d^2z}{dt^2} C_{x'z}$

10.00 $\frac{d^2y'}{dt^2} = \frac{d^2x}{dt^2} C_{y'x} + \frac{d^2y}{dt^2} C_{y'y} + \frac{d^2z}{dt^2} C_{y'z}$

11.00

$\frac{d^2z'}{dt^2} = \frac{d^2x}{dt^2} C_{z'x} + \frac{d^2y}{dt^2} C_{z'y} + \frac{d^2z}{dt^2} C_{z'z}$.

12.00

1.00 Since S is an inertial frame. Let particle does not experience any force is S frame $\therefore a = 0$

2.00

$\Rightarrow \frac{d^2x}{dt^2} = \frac{d^2y}{dt^2} = \frac{d^2z}{dt^2} = 0$.

3.00

$\therefore$ we get $\frac{d^2x'}{dt^2} = \frac{d^2y'}{dt^2} = \frac{d^2z'}{dt^2} = 0$

4.00

$\Rightarrow$ S' frame is also an inertial f.o.r.

5.00

$\therefore$ Transformation Eqn. (1) (2) & (3) are Galilean Transf

6.00 Eqn. from S (inertial f.o.r) to S' (inertial f.o.r.)

7.00 Inverse Galilean Transf. Eqn. from $S' \to S$ are

$x = x' C_{xx'} + y' C_{xy'} + z' C_{xz'}$.

8.00

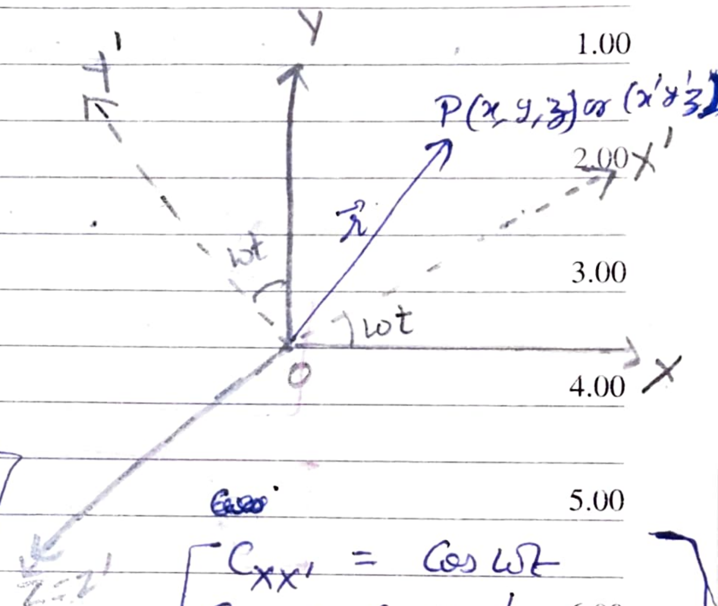
$y = x' C_{yx'} + y' C_{yy'} + z' C_{yz'}$

9.00

$z = x' C_{zx'} + y' C_{zy'} + z' C_{zz'}$.

Transformation Eqn. for a Rotating frame of Ref.

Consider an inertial frame of ref. S and another ref frame S' whose origin and coord. axes coincide with those of S initially. Now let S' starts rotating with a uniform ang. vel ω about common axis of z. $\therefore$ after time t axis OX' & OY' of S' have turned through ωt w.r.t OX & OY.



From last Section

$$x' = x\,C_{xx'} + y\,C_{yx'} + z\,C_{zx'}$$

$$y' = x\,C_{y'x} + y\,C_{y'y} + z\,C_{y'z}$$

$$z' = z$$

$$C_{y'x} = \cos Y'OX = \cos\left(\frac{\pi}{2}+\omega t\right) = -\sin\omega t$$

$$C_{y'y} = \cos Y'OY = \cos\omega t$$

$$C_{y'z} = \cos Y'OZ = \cos\frac{\pi}{2} = 0$$

$$C_{xx'} = \cos\omega t$$

$$C_{yx'} = \cos YOX' = \cos\left(\frac{\pi}{2}-\omega t\right) = \sin\omega t$$

$$C_{zx'} = \cos X'OZ = \cos\frac{\pi}{2} = 0$$

$\therefore$

$$x' = x\cos\omega t + y\sin\omega t \quad \text{--- (1)}$$

$$y' = -x\sin\omega t + y\cos\omega t \quad \text{--- (2)}$$

$$z' = z \quad \text{--- (3)}$$

$$\boxed{\begin{aligned} x &= x'\cos\omega t - y'\sin\omega t \\ y &= x'\sin\omega t + y'\cos\omega t \\ z &= z^2 \end{aligned}}$$

Inverse Transf. Eqn.

Relations (1) $\rightarrow$ (3) are called in frame of ref. S' rotating with a uniform ang. vel ω w.r.t inertial frame S.

$$\therefore \frac{dx'}{dt} = -\omega x \sin\omega t + \omega y \cos\omega t + \frac{dx}{dt}\cos\omega t + \frac{dy}{dt}\sin\omega t$$

$$\Rightarrow \boxed{\frac{dx'}{dt} = \omega y' + \frac{dx}{dt}\cos\omega t + \frac{dy}{dt}\sin\omega t} \quad \text{—— (4)}$$

$$\Rightarrow \frac{d^2x'}{dt^2} = \omega\frac{dy'}{dt} + \frac{dx}{dt}(-\omega\sin\omega t) + \frac{d^2x}{dt^2}\cos\omega t + \frac{dy}{dt}(\omega\cos\omega t) + \frac{d^2y}{dt^2}(\sin\omega t)$$

$$\Rightarrow \frac{d^2x'}{dt^2} = \omega\frac{dy'}{dt} + \omega\left[-\frac{dx}{dt}\sin\omega t + \frac{dy}{dt}\cos\omega t\right] + \frac{d^2x}{dt^2}\cos\omega t + \frac{d^2y}{dt^2}\sin\omega t$$

Similarly $\frac{dy'}{dt} = -\omega x\cos\omega t - \omega y\sin\omega t - \frac{dx}{dt}\sin\omega t + \frac{dy}{dt}\cos\omega t$

$$\boxed{\frac{dy'}{dt} = -\omega x' - \frac{dx}{dt}\sin\omega t + \frac{dy}{dt}\cos\omega t} \quad \text{—— (5)}$$

$$\& \quad \boxed{\frac{dz'}{dt} = \frac{dz}{dt}} \quad \text{—— (6)}$$

Now diff. again (4) (5) & (6) w.r.t t ——

$$\frac{d^2x'}{dt^2} = \omega\frac{dy'}{dt} + \omega\left[-\frac{dx}{dt}\sin\omega t + \frac{dy}{dt}\cos\omega t\right] + \frac{d^2x}{dt^2}\cos\omega t + \frac{d^2y}{dt^2}\sin\omega t$$

$$= \omega\frac{dy'}{dt} + \omega\left[\frac{dy'}{dt} + \omega x'\right] + \frac{d^2x}{dt^2}\cos\omega t + \frac{d^2y}{dt^2}\sin\omega t$$

$$\& \quad \frac{d^2y'}{dt^2} = -\omega\frac{dx'}{dt} + \left[-\omega\frac{dx}{dt}\cos\omega t - \omega\frac{dy}{dt}\sin\omega t\right] - \frac{d^2x}{dt^2}\sin\omega t + \frac{d^2y}{dt^2}\cos\omega t$$

$$= -\omega\frac{dx'}{dt} - \omega\left(\frac{dx'}{dt} - \omega y'\right) + \frac{d^2y}{dt^2}\cos\omega t - \frac{d^2x}{dt^2}\sin\omega t$$

9.00

$$\& \quad \frac{d^2z'}{dt^2} = \frac{d^2z}{dt^2}$$

Now Suppose P is at rest in frame S $\therefore$ acc^n = 0 10.00

$$\Rightarrow \frac{d^2x}{dt^2} = \frac{d^2y}{dt^2} = \frac{d^2z}{dt^2} = 0$$

11.00

$$\therefore \quad \frac{d^2x'}{dt^2} = 2\omega\frac{dy'}{dt} + \omega^2 x'$$

12.00

$$\frac{d^2y'}{dt^2} = -2\omega\frac{dx'}{dt} + \omega^2 y'$$

1.00

$$\& \quad \frac{d^2z'}{dt^2} = 0.$$

2.00

$\Rightarrow$ a force seems to be acting on it in frame S' producing an acc^n in it. $\therefore$ S' is ~~not~~ a non inertial f.o.r. 3.00

4.00

$\therefore$ NOTE Therefore (i) f.o.r in accelerated translation motion w.r.t an inertial f.o.r. 5.00

& (ii) a reference frame in uniform rotation about an inertial frame of ref. 6.00

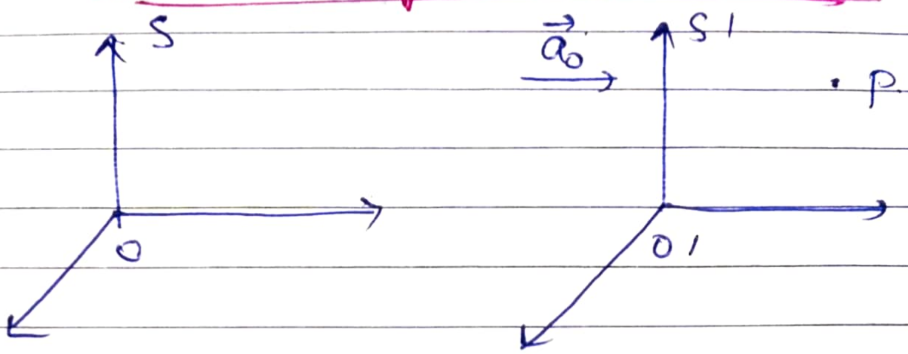
are both non-inertial f.o.r.

7.00

The forces which acts on the particles in these f.o.r. are called fictitious forces. 8.00

9.00

Non-Inertial frames — Fictitious forces.



S' is moving with acc^n a_0 w.r.t S

$\therefore \quad \vec{a}' = \vec{a} - \vec{a_0}$

$\Rightarrow \boxed{\vec{F_N} = \vec{F_I} + \vec{F_0}}$ $\boxed{\because \vec{F_0} = -m\vec{a_0}}$

$\vec{F_N}$ = force in Non-Inertial
$\vec{F_I}$ = " " Inertial
$\vec{F_0}$ = fictitious force ($\because$ it is not an actual force)

Ex: of fictitious forces

(1) Lift is moving downward with acc^n g containing a ball of mass m.

$\therefore$ force on ball in inertial f.o.r $= \vec{F_I} = (mg)$ $\{\because a_0 = g\}$

& fictitious force on ball $= -m(\vec{a_0}) = -m(\vec{g}) = \vec{F_0} = mg$

$\therefore$ force in Non-Inertial f.o.r $= \vec{F_I} + \vec{F_0}$

$= mg - mg = 0$

ie. particle is weightless and thus remains suspended in the air. It is same as condition obtained in artificial sattelite.

NOTE: (1) If 2 frames be in uniform motion (zero acc^n) w.r.t eachother, they are inertial f.o.r and it is impossible to find out which one is at rest & which one in motion.

(2) If however one of them be accelerated w.r.t other

fictitious force comes into play inside the accelerated frame. These forces are different from true or real forces.

4) If our frame is inertial frame, fictitious force → 0 i.e. it go on diminishing rapidly with distance and almost zero at large distance.

5) If our frame is accelerated frame i.e. non inertial then the real forces on particle or bodies at large distance from other bodies are negligible. But fictitious forces goes on increasing.

Prob: Calculate the fictitious force and observed force on a body of mass 5 kg in a frame of reference moving (i) vertically upward
(ii) vertically downward with $a = 4\, m/s^2$

Let earth → Inertial f.o.r. & upward dir^n → +ve.

Case (I) True weight of the body $\vec{F}_I = mg\ (-ve)$

$= 5(-9.8) = -49\ N$

$\Rightarrow$ 49 N in downward dir^n.

fictitious force acting on body $= F_0 = -ma_0$

$= -5(4) = -20\,N$

$\Rightarrow$ 20 N in downward dir^n.

Total force observed on body $F_N = F_I + F_0$

$= -49 - 20\ N$

$= -69\ N$

$\Rightarrow$ 69.0 N in downward dir^n.

$\Rightarrow$ weight of the body ~~becom~~ feels greater than the original weight

~~Lift or Fo's moving~~ ~~$ma = mg + ma_0 = m(a_0+g)$~~ ~~if $a_0 = g$ $\therefore ma' = 0$ weightless~~ ~~$\therefore ma' = -mg - ma_0$~~

Case (II) True force acting on body $= mg$
$$= m(-9.8)$$
$$\vec{F_I} = -49\,N.$$

fictitious force " " " $\vec{F_0} = -ma$
$$= -5(-4) \quad \left\{ \because a = -4\,m/s^2 \right.$$
$$= 20\,N.$$

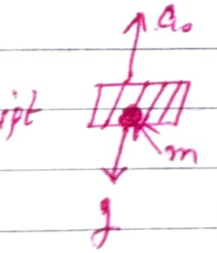
$\therefore$ Total observed force on body $= -49 + 20$
$$\vec{F} = -29\,N$$

$\Rightarrow$ 29 N downwards

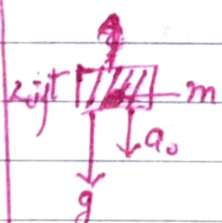
Prob: A frame of ref. is moving with an acc^n of 5 m/s² downward. Find the apparent force & total force acting on a body of mass 10 kg falling freely relative to frame.

Sol) As the body is falling freely, downward force on it in the inertial frame of the earth
$$\vec{F_I} = 0$$
$$\therefore \vec{F_N} = +\vec{F_0} \quad \forall \quad \vec{F_0} = -ma_0$$
$$= -10(-5) \quad \left\{ \because a_0 = -5\,m/s^2 \right.$$
$$= +50\,N.$$

$\therefore$ 50 N upwards is the Total force acting on body



$ma' = -mg - m(a_0)$
$= -m(g + a_0)$
ie body becomes heavier than original weight



$ma' = -mg - m(-a_0)$
$= -m(g - a_0)$
$\therefore$ body feels lighter than the original weight

Case: if $a_0 = g$ $\therefore$ $ma' = 0 \Rightarrow$ Condition of weightlessness