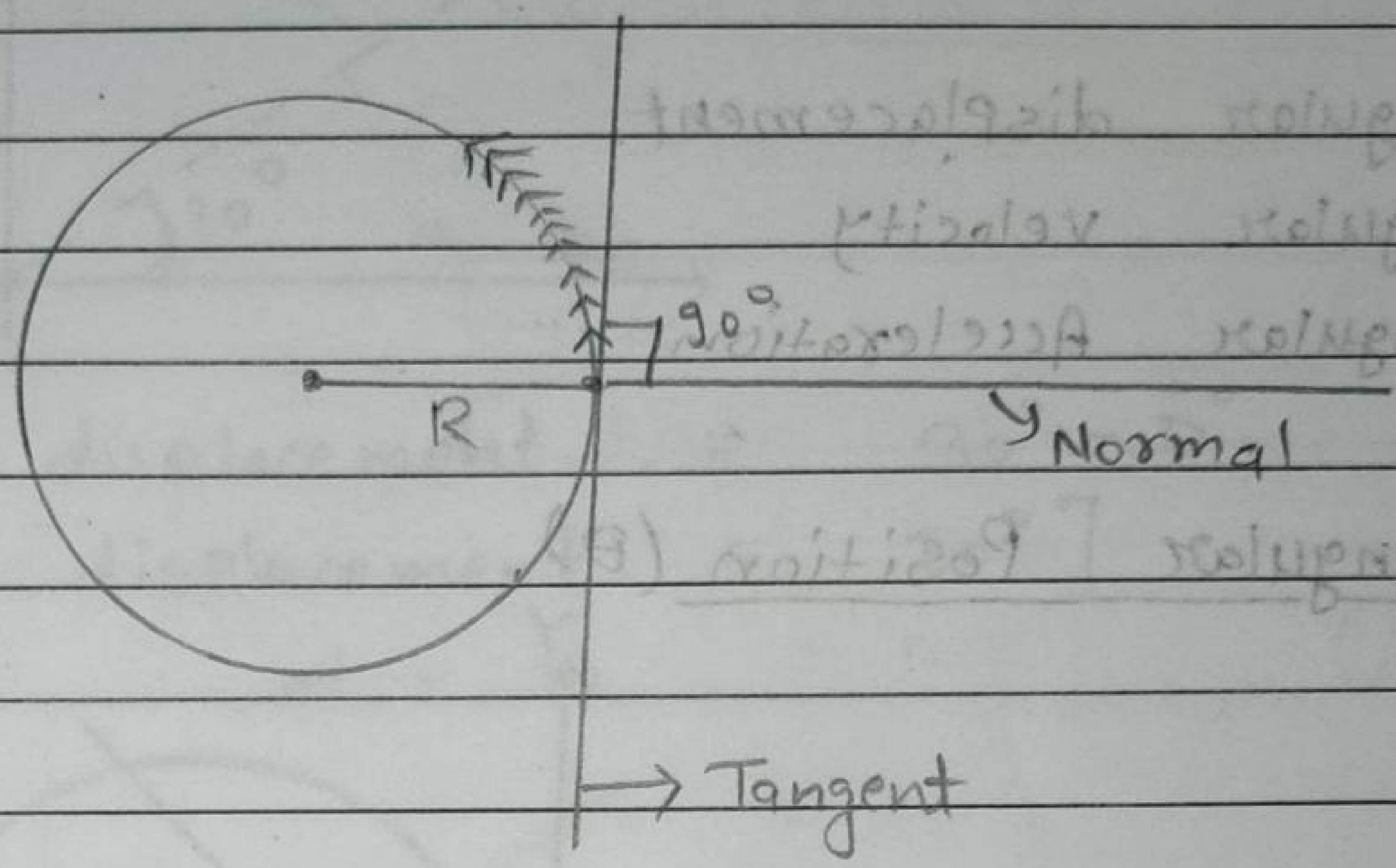
Chapter -

CIRCULAR MOTION

⇒



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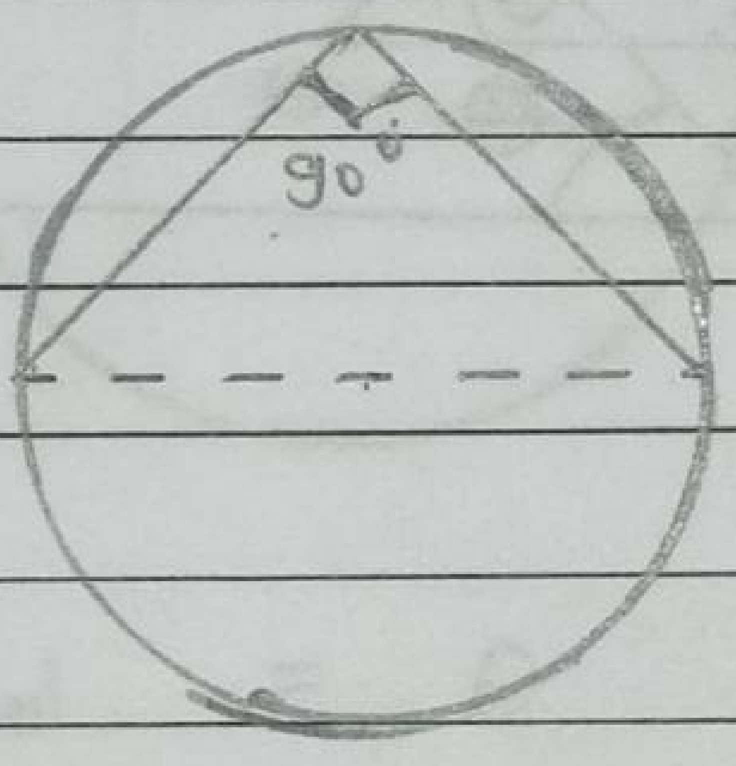


Area $= \pi r^2$

circumference $= 2\pi r$

⇒

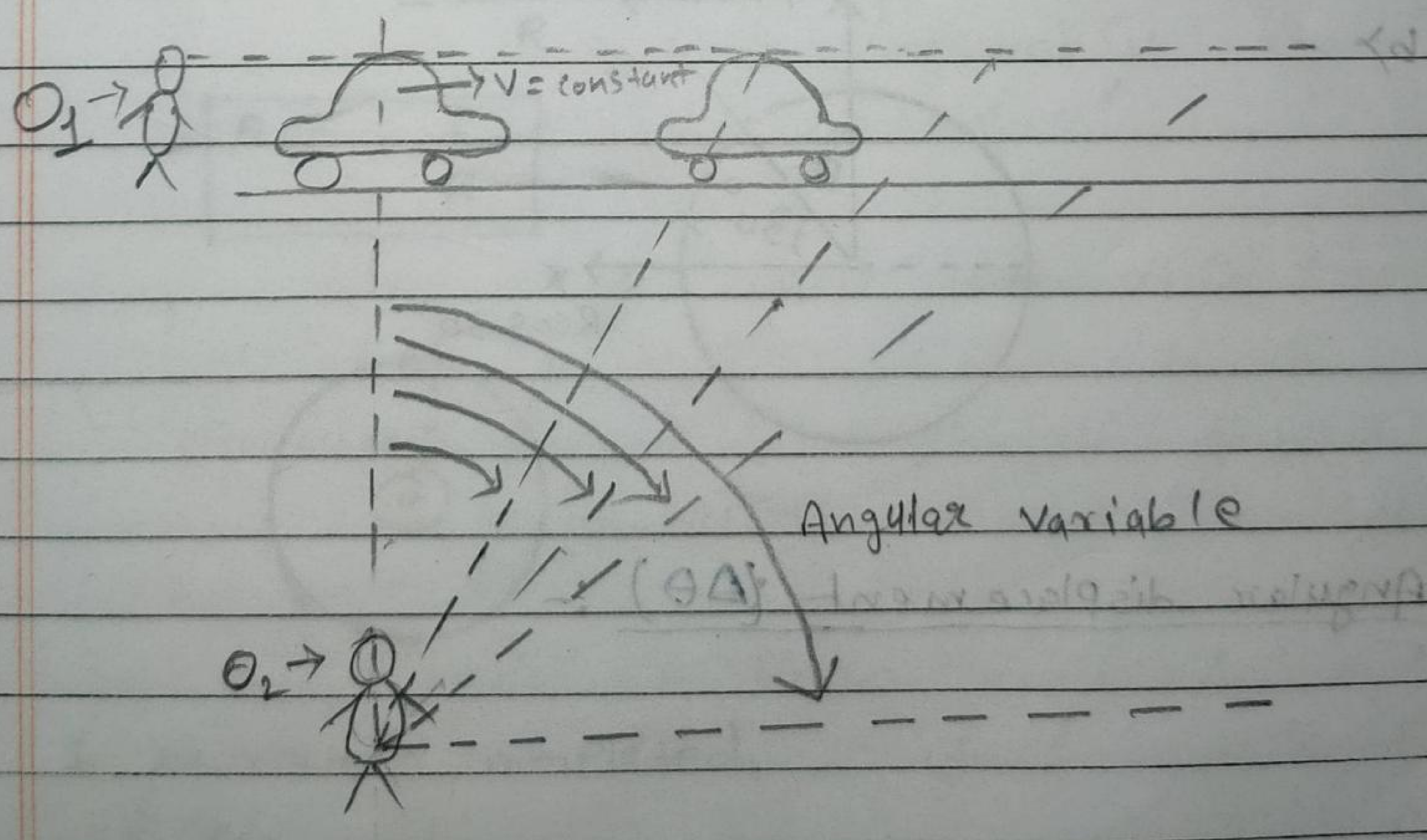


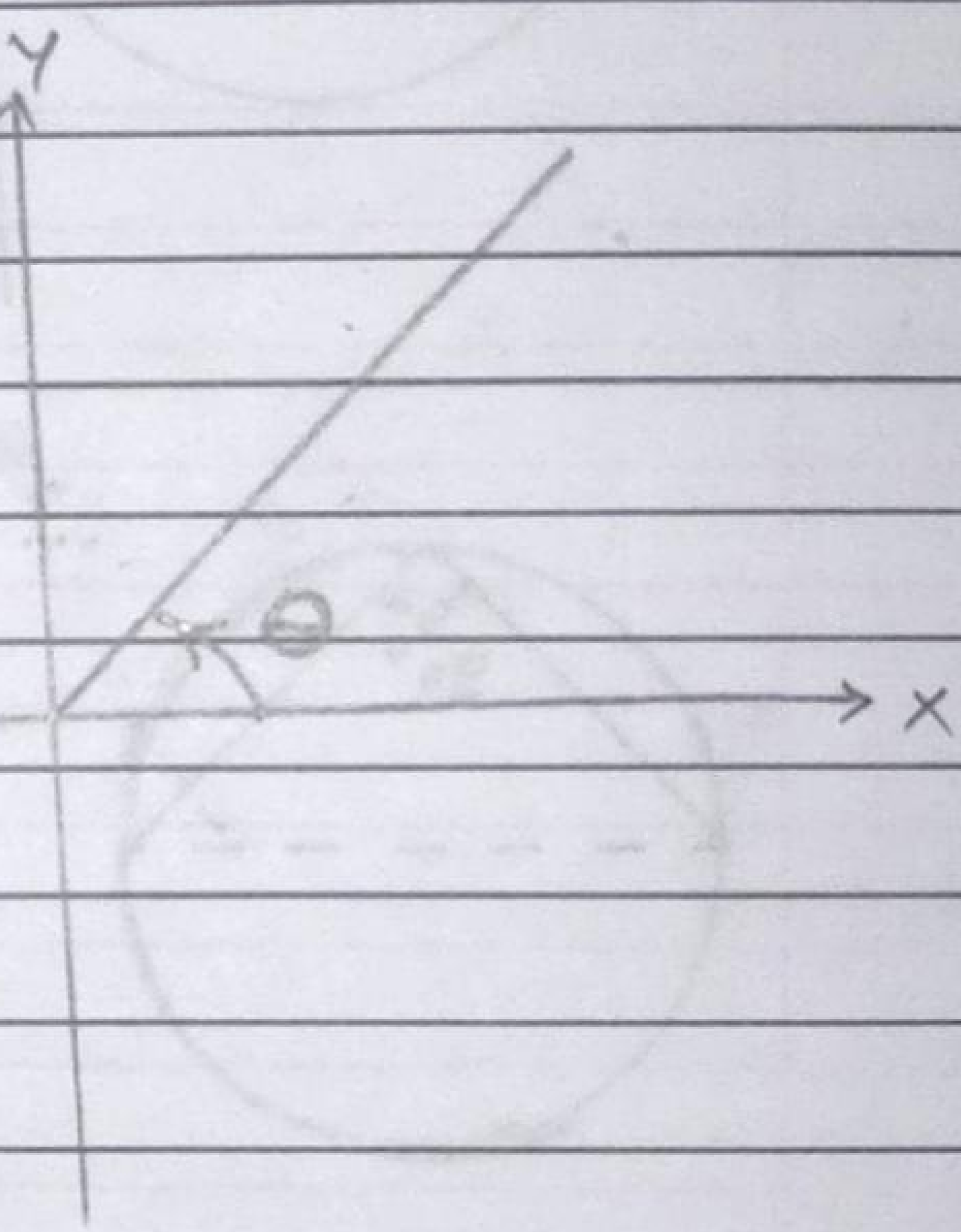
Fig. 1

Angular Variable :-

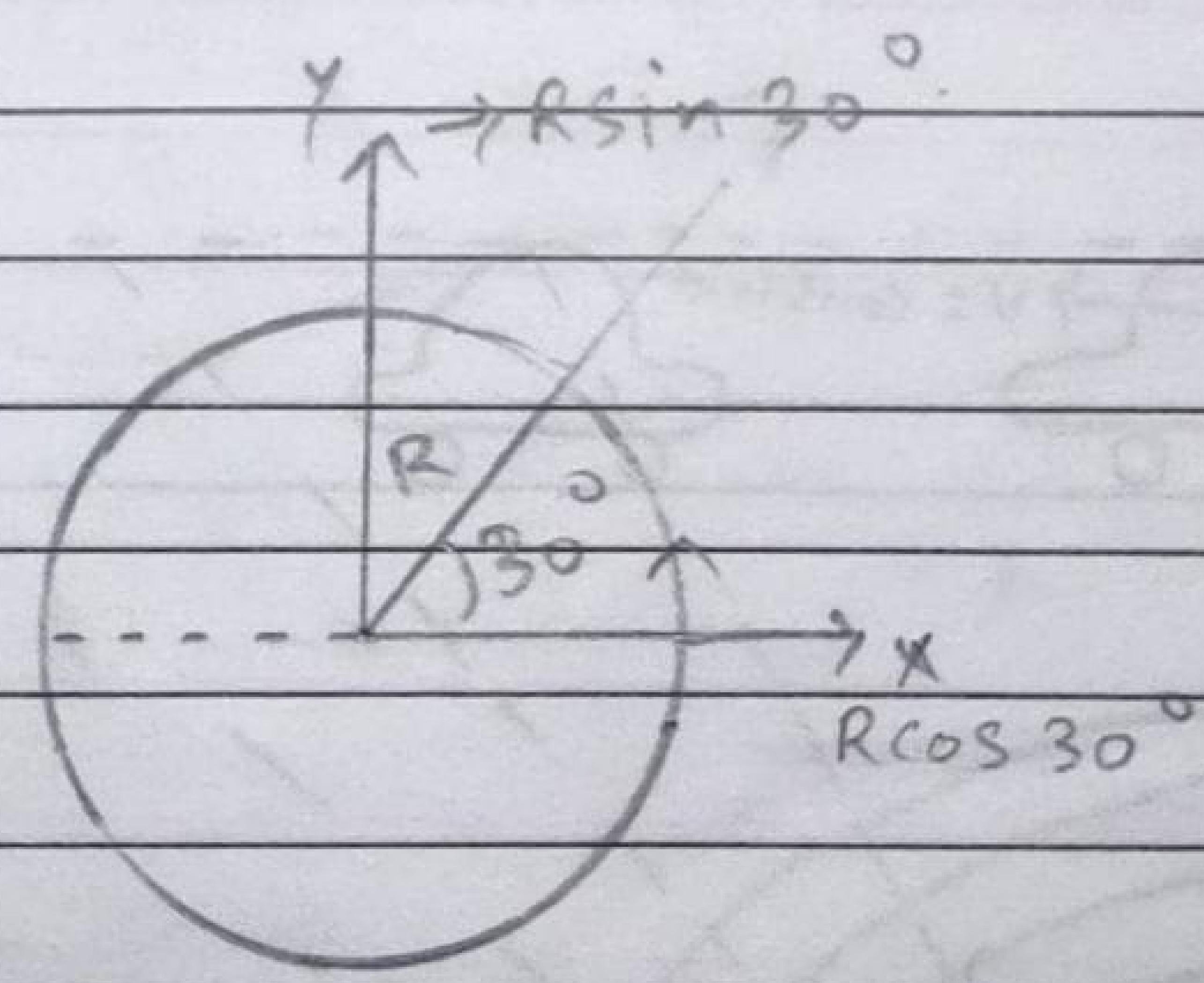
1) Angular displacement
2) Angular velocity
3) Angular Acceleration

*) angular Position (θ)

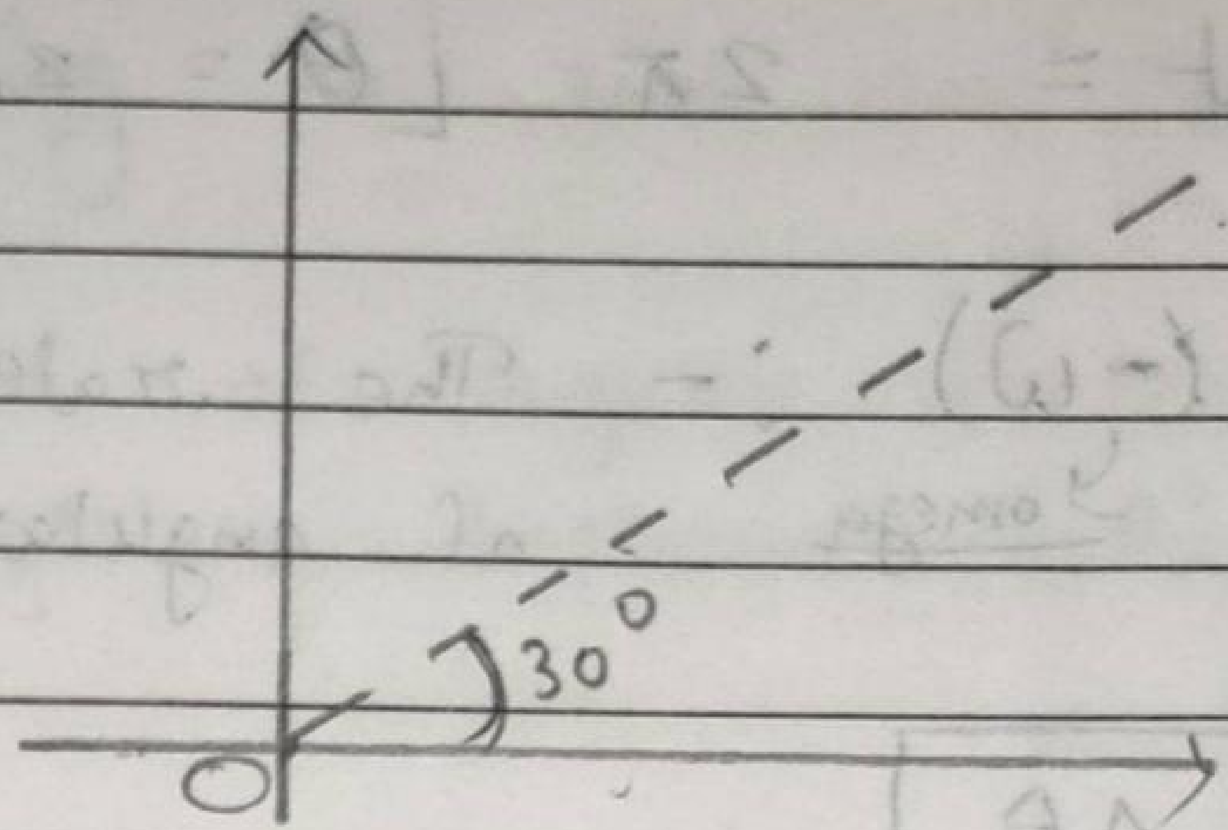
a)



b)

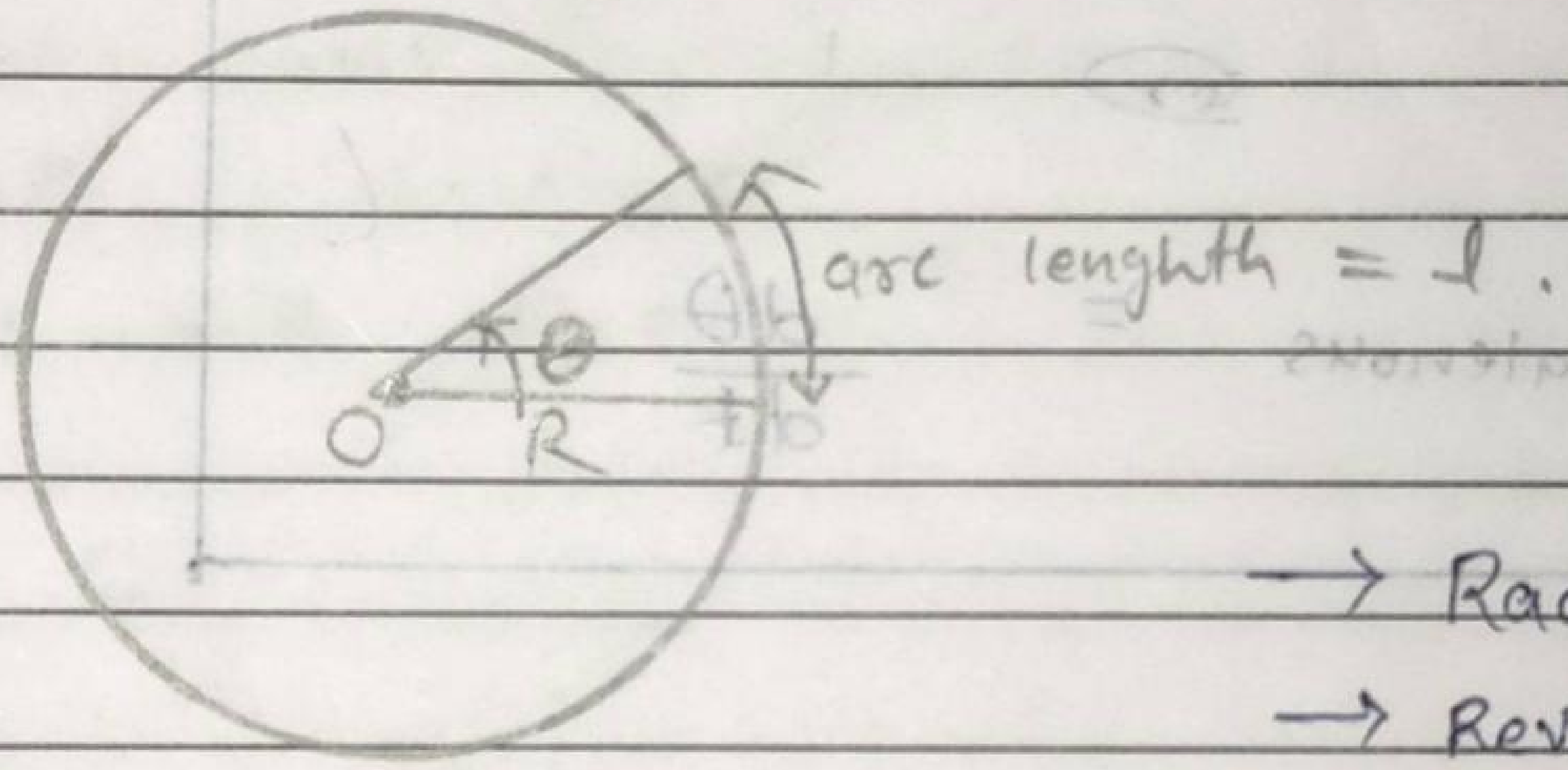


1) Angular displacement ($\Delta\theta$) :-



⇒ Angular displacement = $30^\circ - 0^\circ$.

⇒ Angular displacement = 30°]



→ Radians

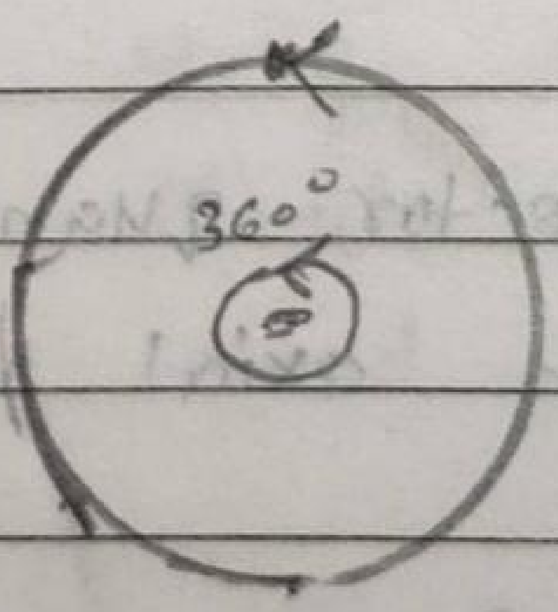
→ Revolutions

⟶ Symbol = θ

⇒ $\theta = \dfrac{\text{arc length}}{R}$

$$\boxed{\theta = \frac{l}{R}}$$

Q.



1 revolution completed.

1 sec.

Angular displacement = 2π $[\theta = 2\pi]$

2) Angular Velocity (ω) :- The rate of change of angular displacement

omega

$$\boxed{\omega_{average} = \frac{\Delta\theta}{\Delta t}}$$

$$\omega_{instatenous} = \lim_{\Delta t \to 0} \frac{\Delta\theta}{\Delta t}$$

or

$$\omega_{instatenous} = \frac{d\theta}{dt}$$

Unit :- $\frac{\text{radian}}{\text{sec}}$

= radian / sec.

→ ω (omega)
→ vector quantity

→ θ = axial vector

* Angular velocity is a vector quantity
* This is because θ is an axial vector.

* For direction curve the fingers of your right hand along the direction of motion of a particle in a circular path then the thumb

will going to give you direction of this vector.

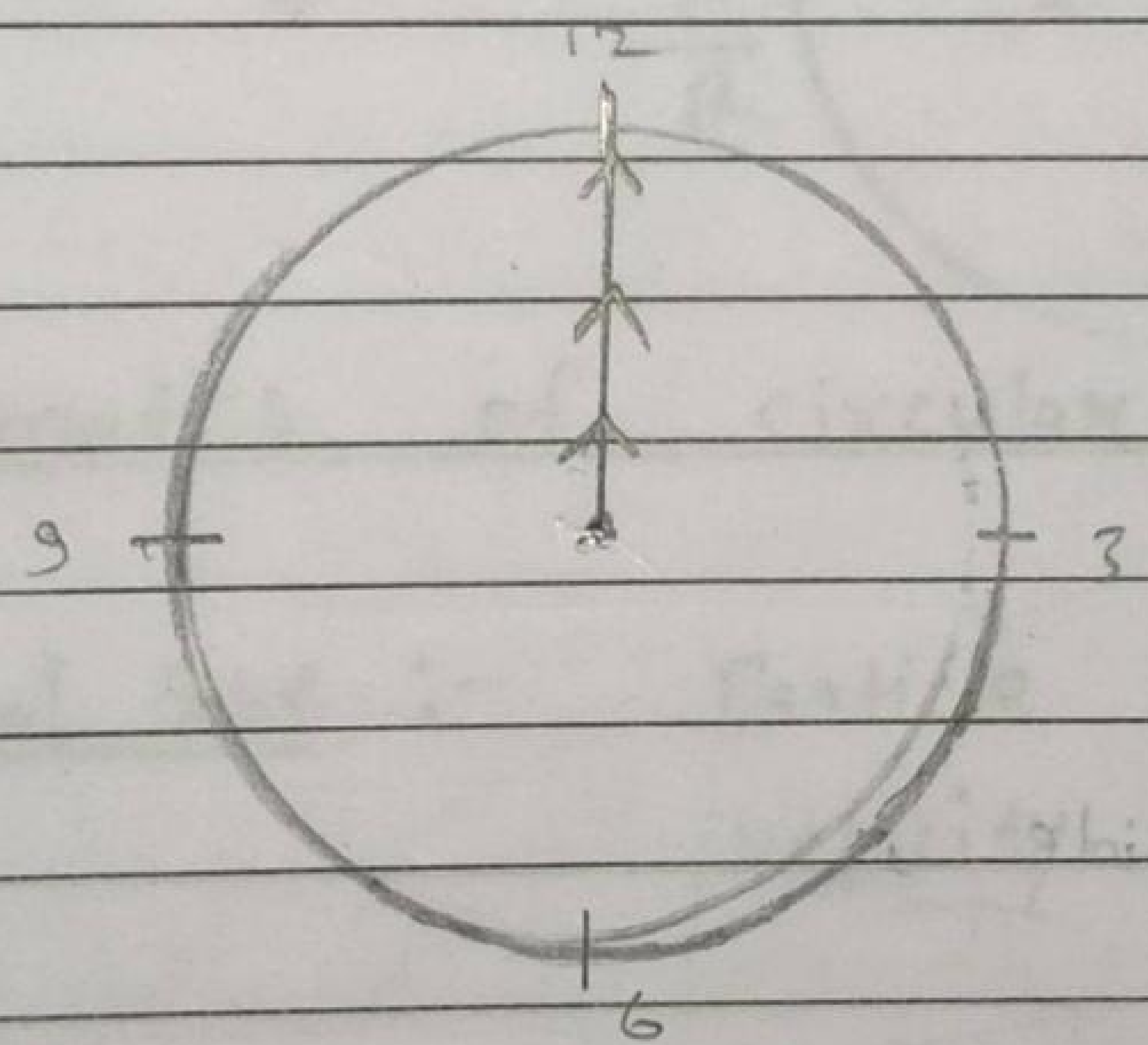
☆ Direction of angular velocity(ω) along the direction of angular displacement (θ).

Q. From Fig 1., the rate of change of angular displacement vector linked with observer ②.-

a) remains same
b) increases with time
✓c) decreases with time
d) None

Ans. ⇒ option C.

Q.



Find Hour, Minute and second had revolution.

Sol. For Hour hand $= 2\pi$

Minute hand $= 12 \times 2\pi = 24\pi$

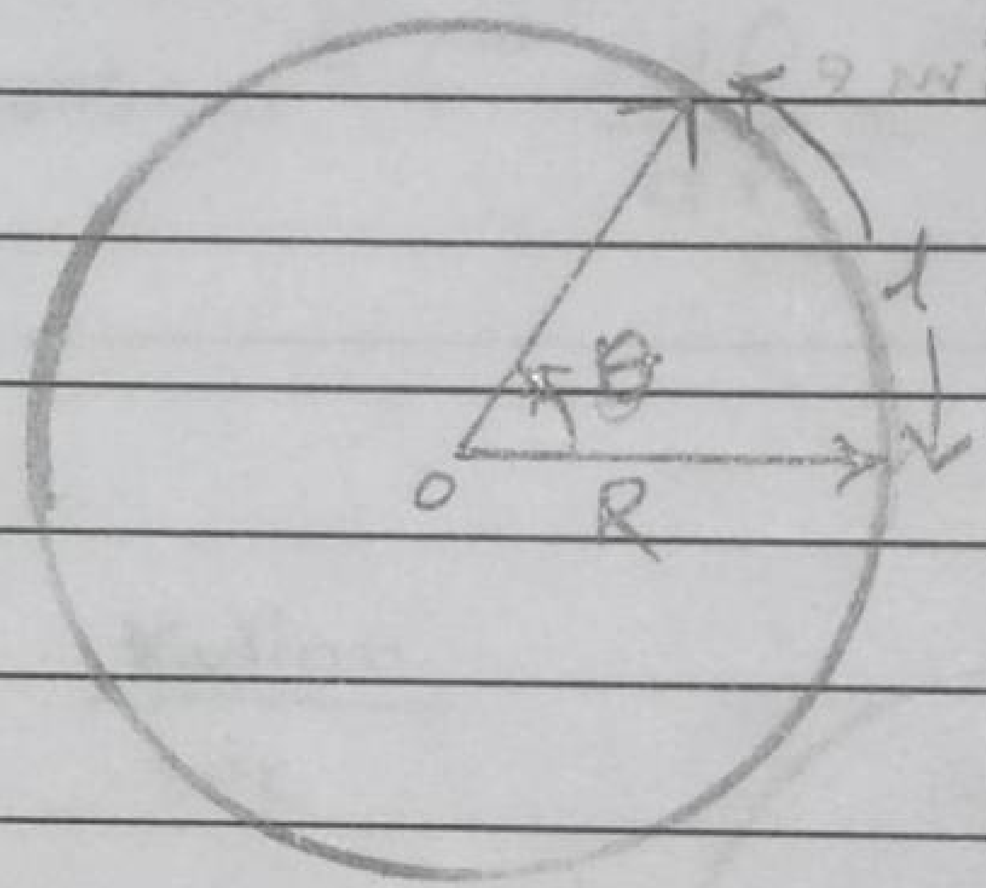
second hand $= 60 \times 12 \times 2\pi = 1440\pi$

3) **Angular Acceleration** {(α) alpha} :- The rate of change of angular displacement.

$$\boxed{\alpha = \frac{d\omega}{dt}}$$ [unit is rad./sec^2]

* Angular acceleration is vector quantity.

Relationship between linear variable and angular variable :-



$$\theta = \frac{l}{R}$$

diffrentiating both side ,

$$\Rightarrow \frac{d}{dt}(\theta) = \frac{d}{dt}\left(\frac{l}{R}\right)$$

$$\Rightarrow \frac{d\theta}{dt} = \frac{1}{R}\left(\frac{dl}{dt}\right)$$

$$\Rightarrow \omega = \frac{1}{R} V$$

$$\Rightarrow \boxed{\omega = \frac{v}{R}} \quad \text{or} \quad \boxed{\vec{V} = R\vec{\omega}}$$

~~Relationship between angular variable~~

and $\alpha = \frac{d\omega}{dt}$

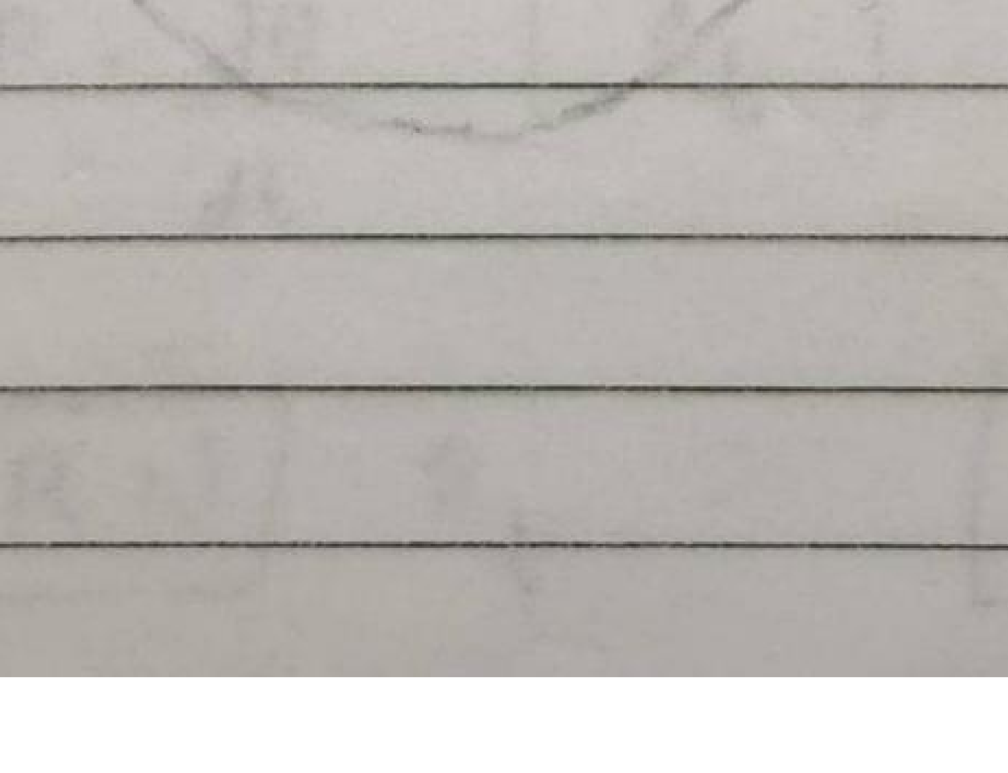
$$\Rightarrow \alpha = \frac{d}{dt} \times \frac{V}{R}$$

$$\Rightarrow \alpha = \frac{dV}{dt} \times \frac{1}{R}$$

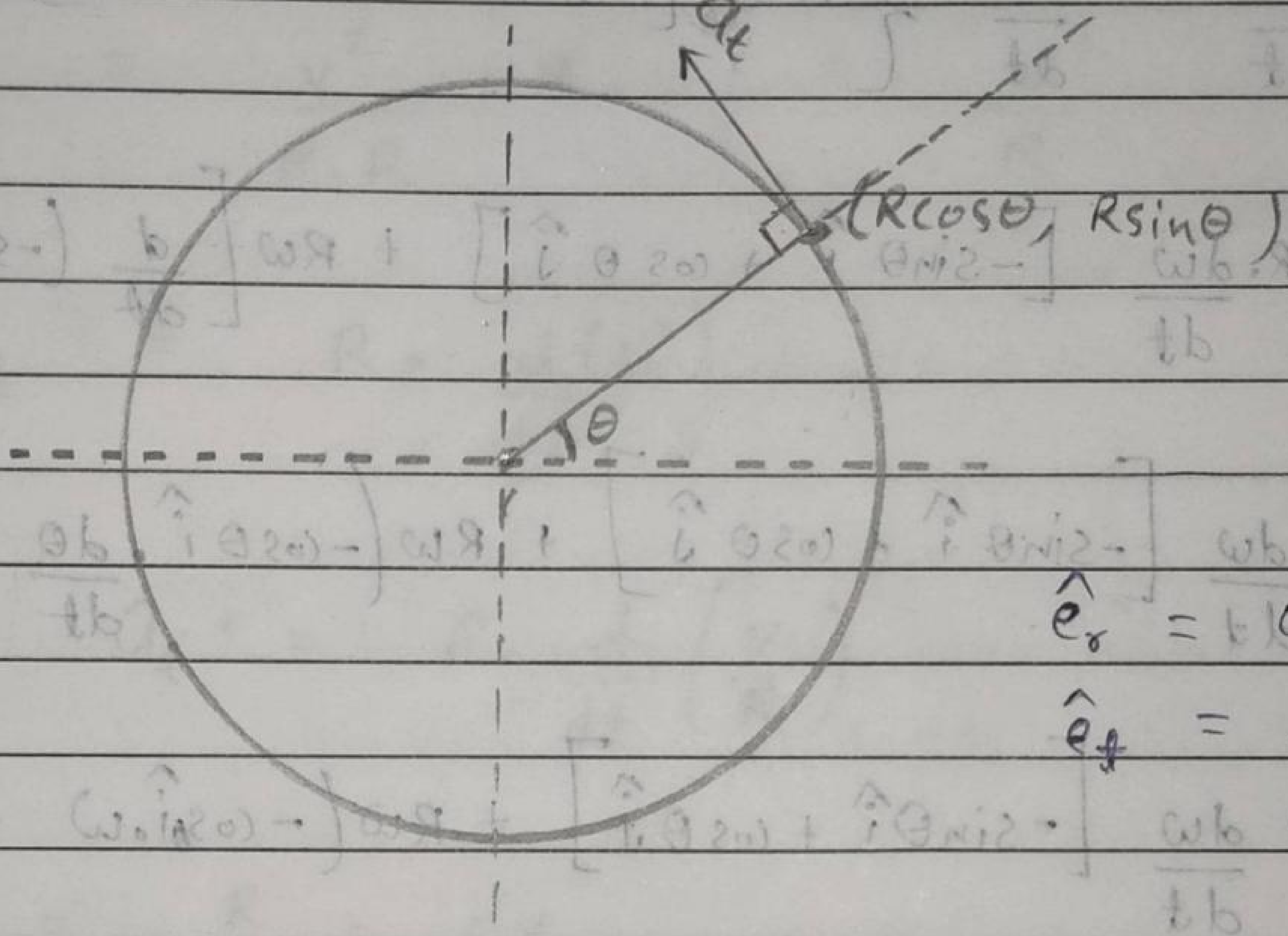
$$\Rightarrow \alpha = \frac{a}{R}$$

Kinematics of circular motion :-

General Case :- Particle is moving with variable linear velocity in circular Path.



Magnitude and direction
<u>both varrying :-</u>



$$\hat{e}_r = \cos\theta\ \hat{i} + \sin\theta\ \hat{j}$$

$$\hat{e}_t = -\sin\theta\ \hat{i} + \cos\theta\ \hat{j}$$

$$\vec{r} = R\cos\theta\ \hat{i} + R\sin\theta\ \hat{j}$$

$$\vec{v} = \frac{d\vec{r}}{dt} = \frac{d}{dt}\left[R\cos\theta\ \hat{i} + R\sin\theta\ \hat{j}\right]$$

$$\vec{v} = R.(-\sin\theta).\frac{d\theta}{dt}\ \hat{i} + R\cos\theta.\frac{d\theta}{dt}\ \hat{j}$$

$$\vec{v} = R.\frac{d\theta}{dt}\left[-\sin\theta\ \hat{i} + \cos\theta\ \hat{j}\right]$$

$$\vec{v} = R.\frac{d\theta}{dt}\left[\hat{e}_t\right]$$

$$\boxed{v = R\omega}\ \hat{e}_t \qquad [\omega = \text{omega}]$$

$$\Rightarrow \vec{v} = R\omega\left[-\sin\theta\,\hat{i} + \cos\theta\,\hat{j}\right]$$

$$\Rightarrow \vec{a} = \frac{d\vec{v}}{dt} = \frac{d}{dt}\left\{R\omega\left[-\sin\theta\,\hat{i} + \cos\theta\,\hat{j}\right]\right\}$$

$$\Rightarrow \vec{a} = R.\frac{d\omega}{dt}\left[-\sin\theta\,\hat{i} + \cos\theta\,\hat{j}\right] + R\omega\left[\frac{d}{dt}\left(-\sin\theta\,\hat{i} + \cos\theta\,\hat{j}\right)\right]$$

$$\Rightarrow \vec{a} = R\frac{d\omega}{dt}\left[-\sin\theta\,\hat{i} + \cos\theta\,\hat{j}\right] + R\omega\left(-\cos\theta\,\hat{i}.\frac{d\theta}{dt} - \sin\theta\,j.\frac{d\theta}{dt}\right)$$

$$\Rightarrow \vec{a} = R\frac{d\omega}{dt}\left[-\sin\theta\,\hat{i} + \cos\theta\,\hat{j}\right] + R\omega\left(-\cos\theta\,\hat{i}.\omega - \sin\theta\,j.\omega\right)$$

$$\Rightarrow \vec{a} = R\frac{d\omega}{dt}\left[-\sin\theta\,\hat{i} + \cos\theta.\,\hat{j}\right] - R\omega^2\left(\cos\theta\,\hat{i} + \sin\theta\,\hat{j}\right)$$

$$\Rightarrow \vec{a} = R.\frac{d\omega}{dt}\,\hat{e}_t - \omega^2 R\,\hat{e}_r$$

$\Rightarrow$ a_t = tangential acceleration

α = angular acceleration,

$\Rightarrow$ ~~at~~ $a_t = R\alpha$

$$\Rightarrow \alpha = \frac{a_t}{R}$$

a_r = radical acceleration = $\omega^2 R$

$$\omega = \frac{V}{R}$$

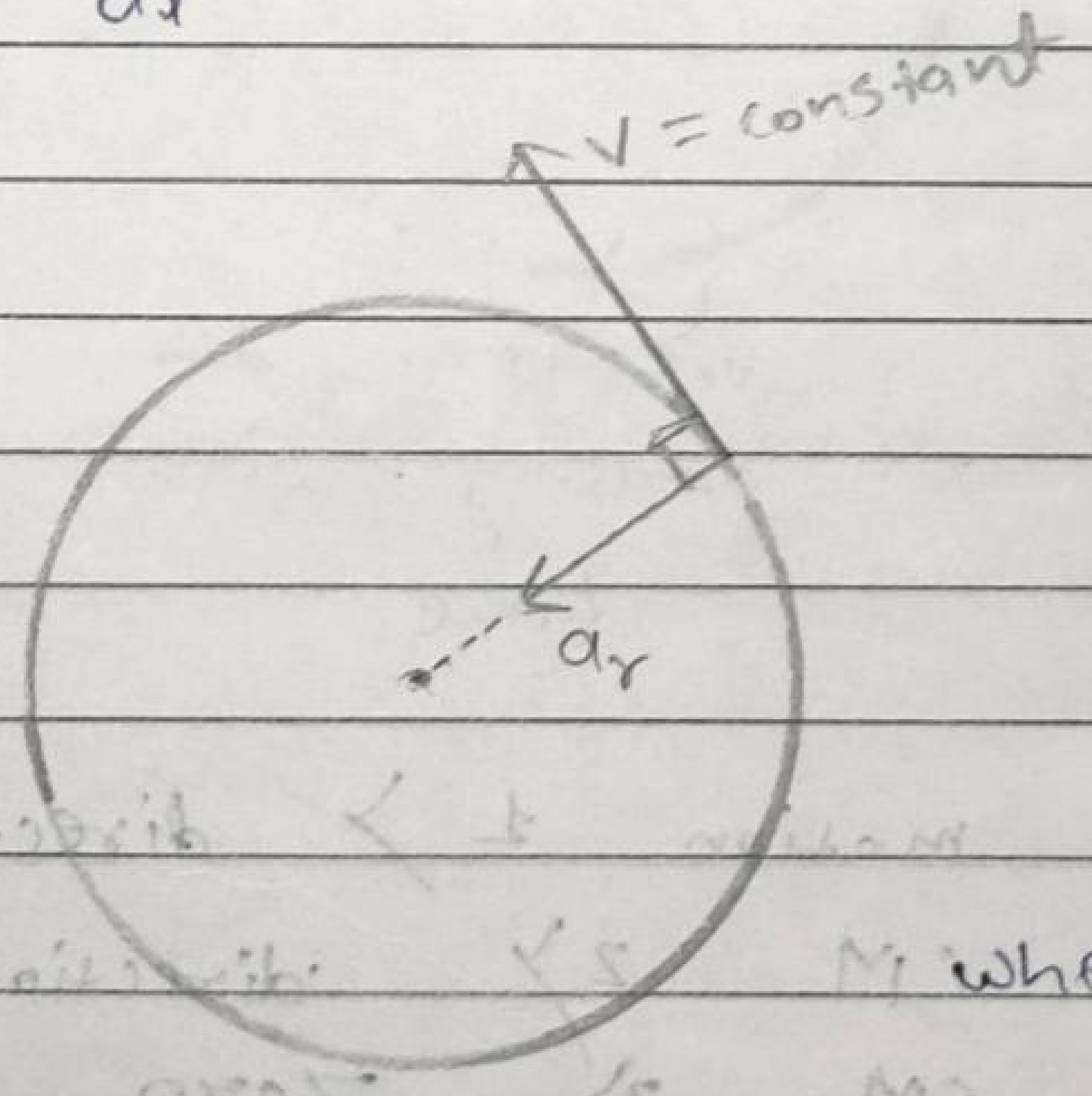
$$a_r = \frac{V^2}{R.R} \times R = \frac{V^2}{R}$$

$$\Rightarrow a_t = R \cdot \frac{d(\omega)}{dt}$$

$$\Rightarrow \cancel{a_t}\ a_t = R \cdot \frac{d}{dt}\left(\frac{V}{R}\right)$$

$$\Rightarrow a_t = \frac{R}{R} \cdot \frac{dv}{dt}$$

$$\Rightarrow a_t = \frac{dv}{dt}$$



when V = constant

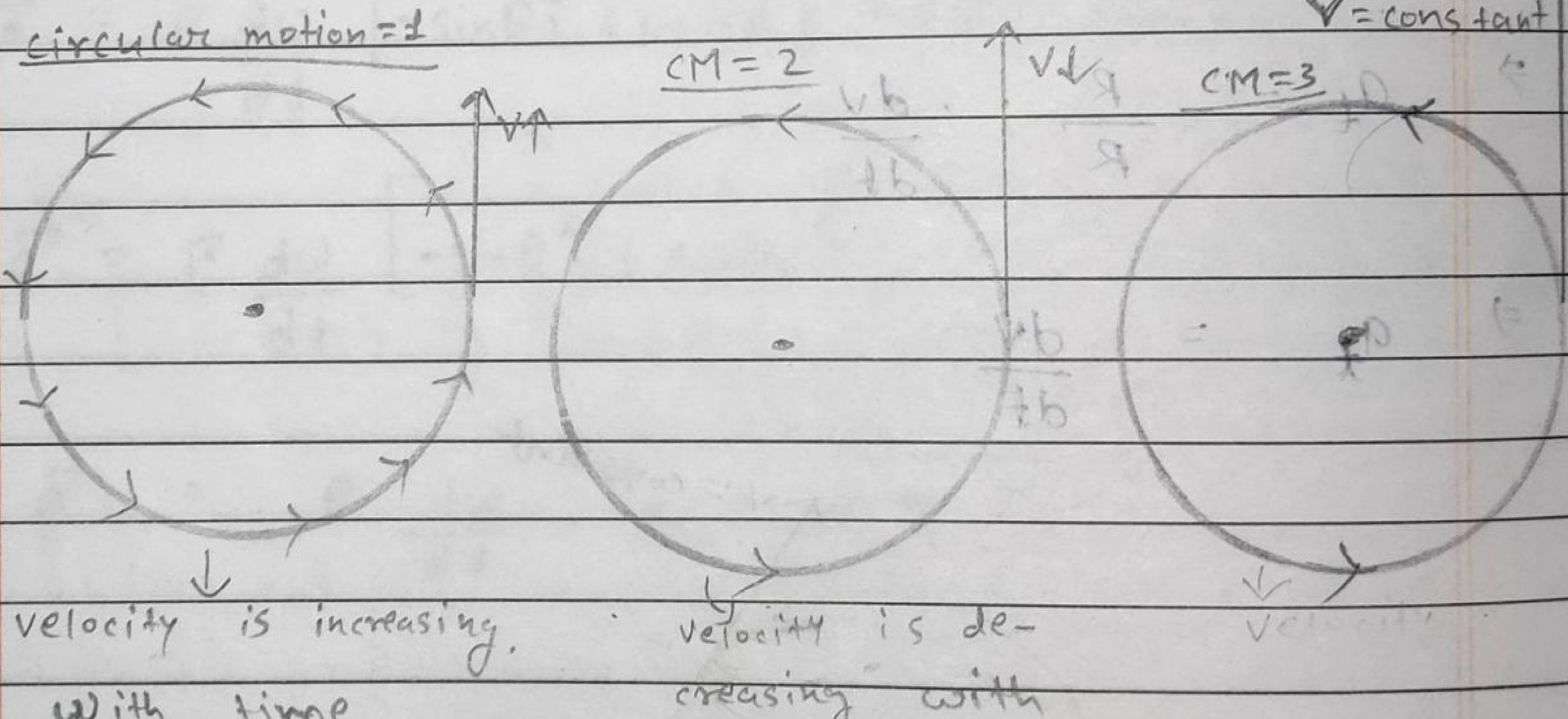
$$\Rightarrow a_t = \frac{dV}{dt}$$

$$\Rightarrow \boxed{\frac{dv}{dt} = 0}$$

* In circular motion 2 acceleration are present, one is along radial direction and other is along tangencial direction. Radial direction acceleration is also known as centrepetal acceleration. Centripetal or Radial acceleration help us to change the direction of a Particle in circular motion.

* Another acceleration is tangencial acceleration whose direction is along the direction of velocity or opposite to direction of velocity.

Q.



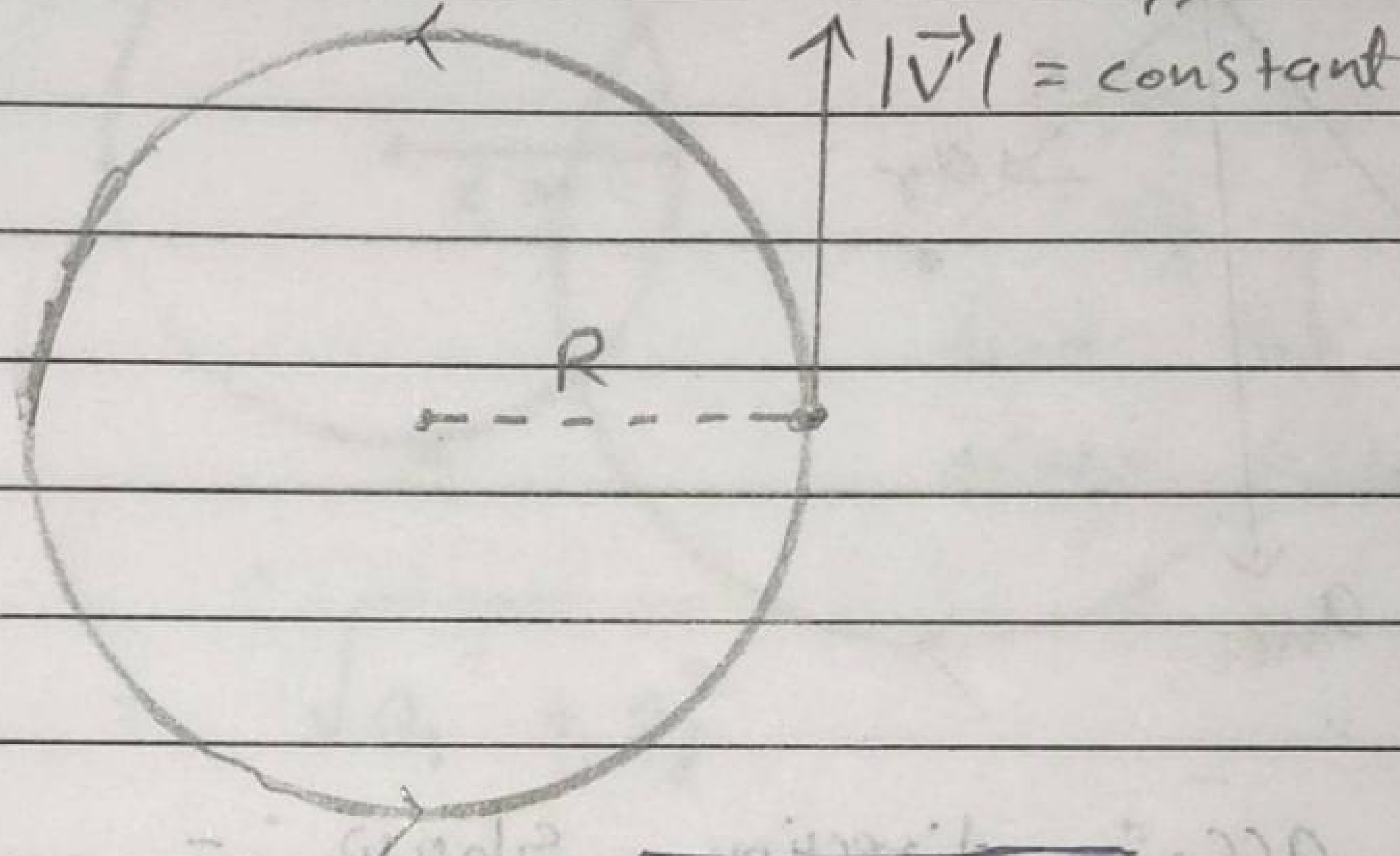
Ans. In circular motion 1 > direction is Positive.
CM 2 > direction is Negative
CM 3 > Zero.

Q. Particle is performing circular motion of radius r with constant speed.

find $a_{net} = ?$

$a_r = ?$

$a_t = ?$



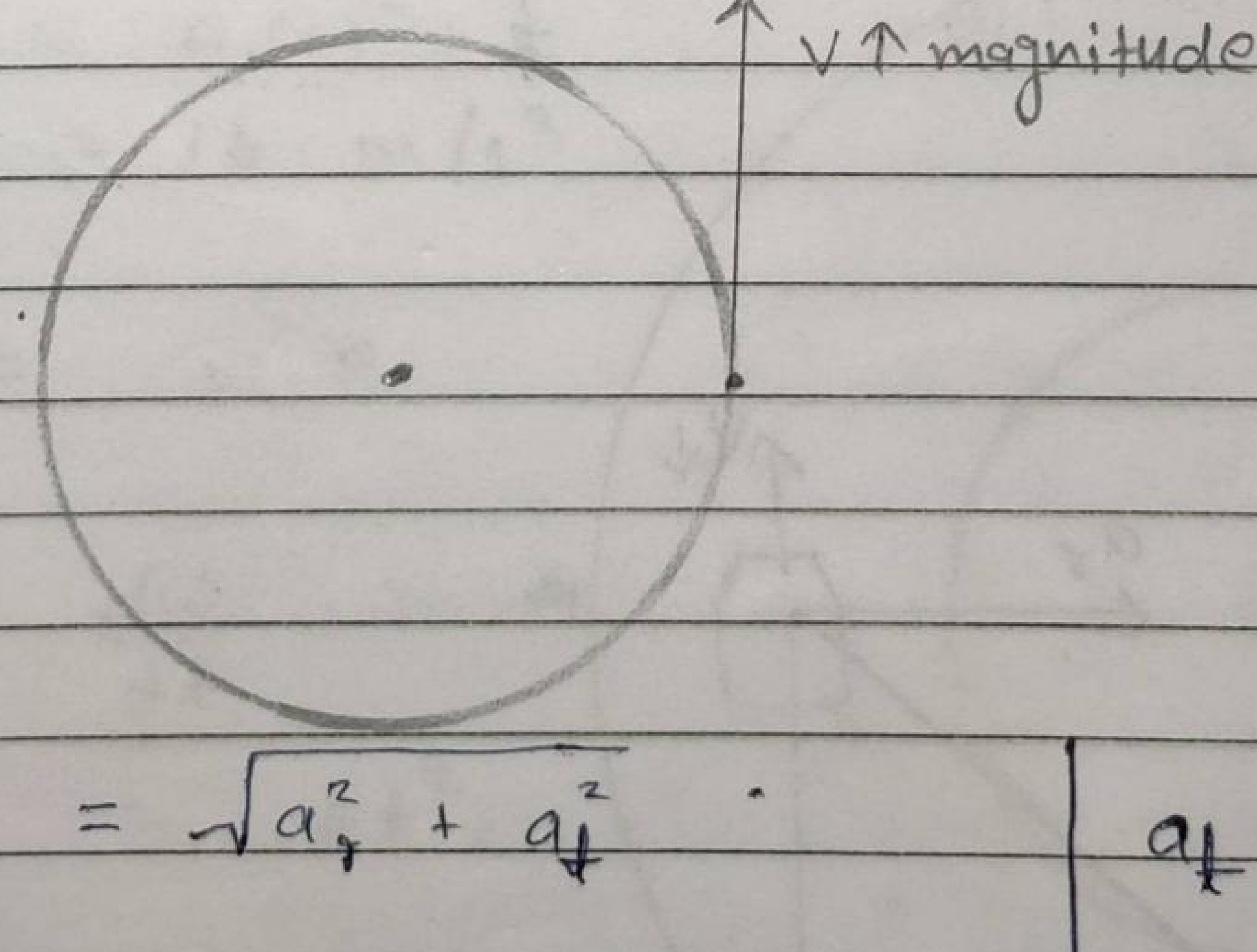
$\Rightarrow$ uniform circular motion.

Ans $a_{net} = \sqrt{a_r^2 + a_t^2} = \omega^2 R = \frac{v^2}{R \cdot R} \times R = \frac{v^2}{R}$

$a_r = \omega^2 R$

$a_t = \frac{dv}{dt} = 0$

Q.



Ans. $a_{net} = \sqrt{a_r^2 + a_t^2}$

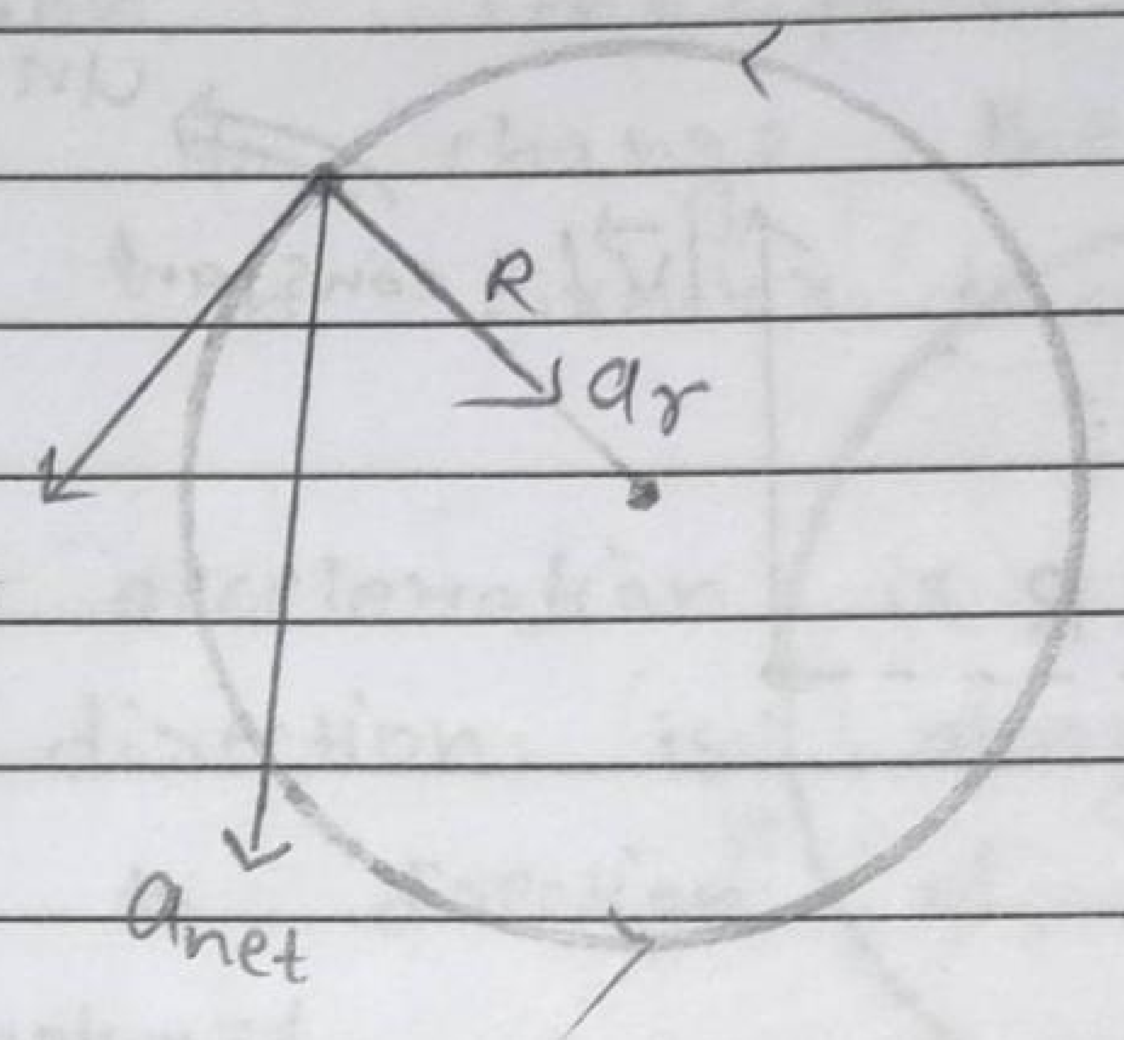
$a_r = \omega^2 R = \frac{v^2}{R}$

$a_t = \frac{dv}{dt}$

$a_t = \frac{d\omega}{dt} \cdot R = \alpha R.$

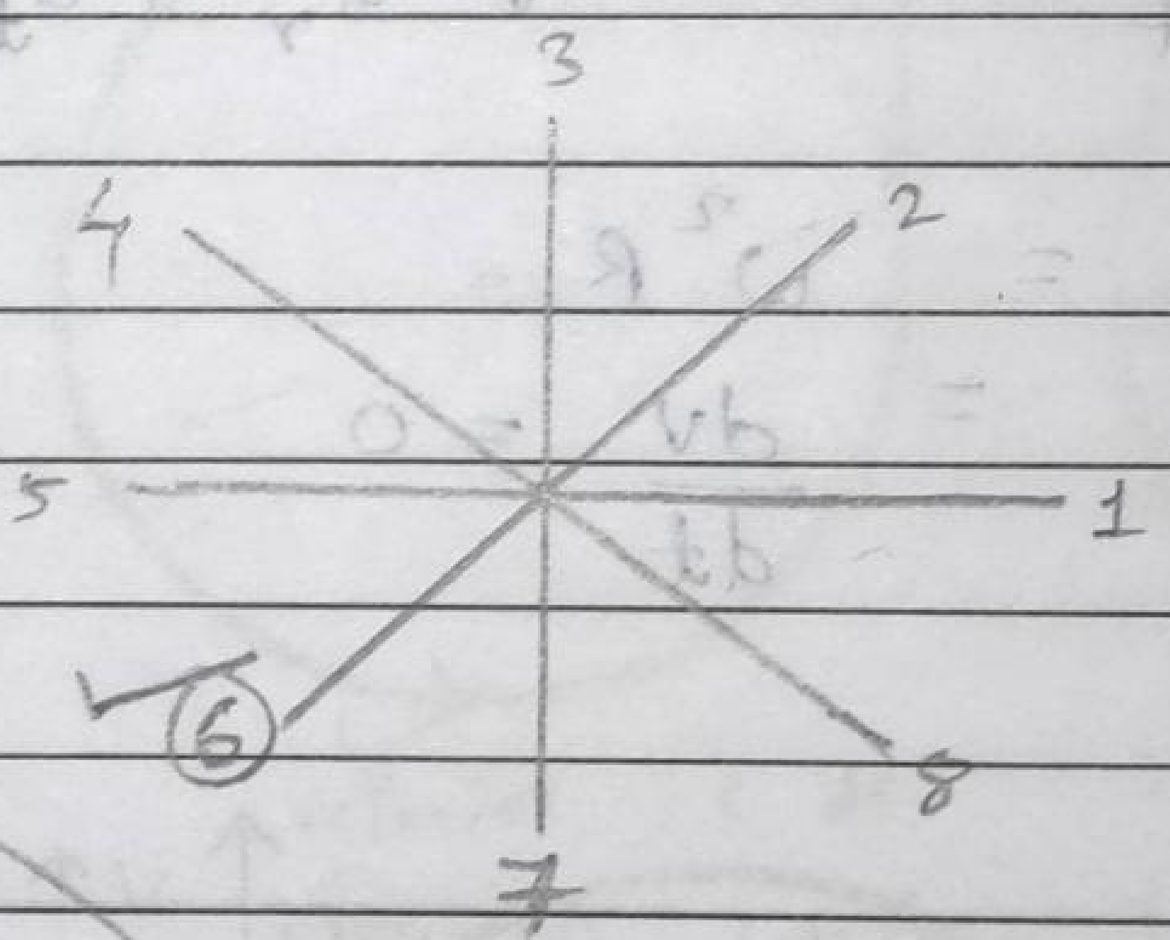
* In Uniform circular Motion $\rightarrow$ Magnitude of velocity is fixed if Magnitude of velocity changes but in both of the cases direction of velocity changes.

Q.)

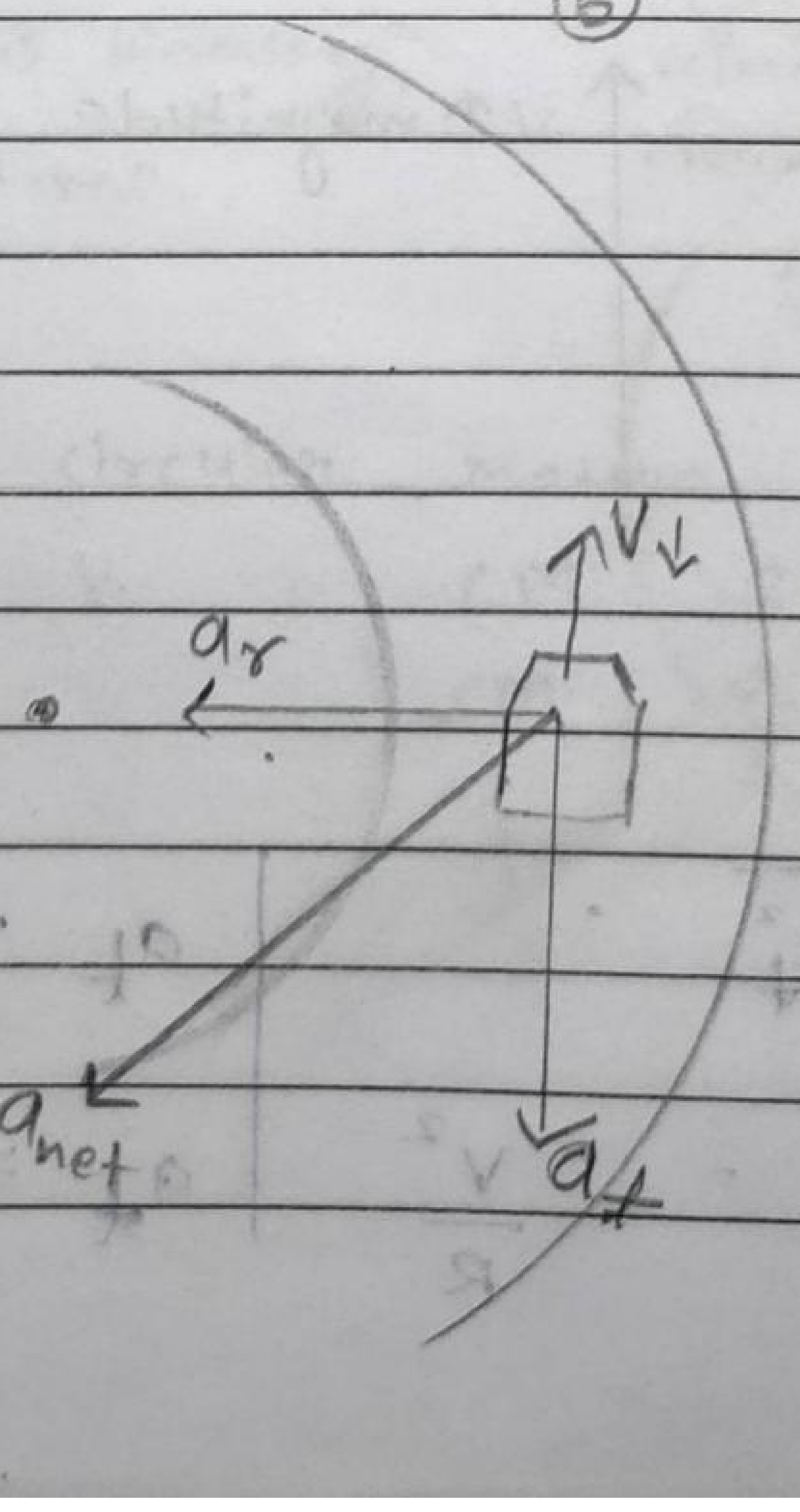


a_{net} acc. direction show :-

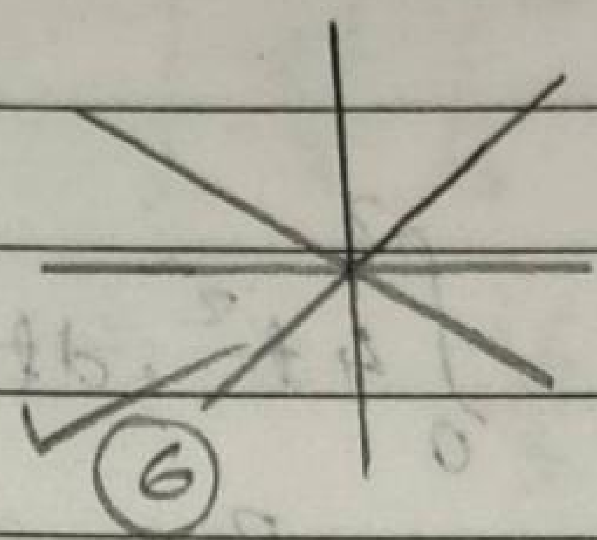
if V↑



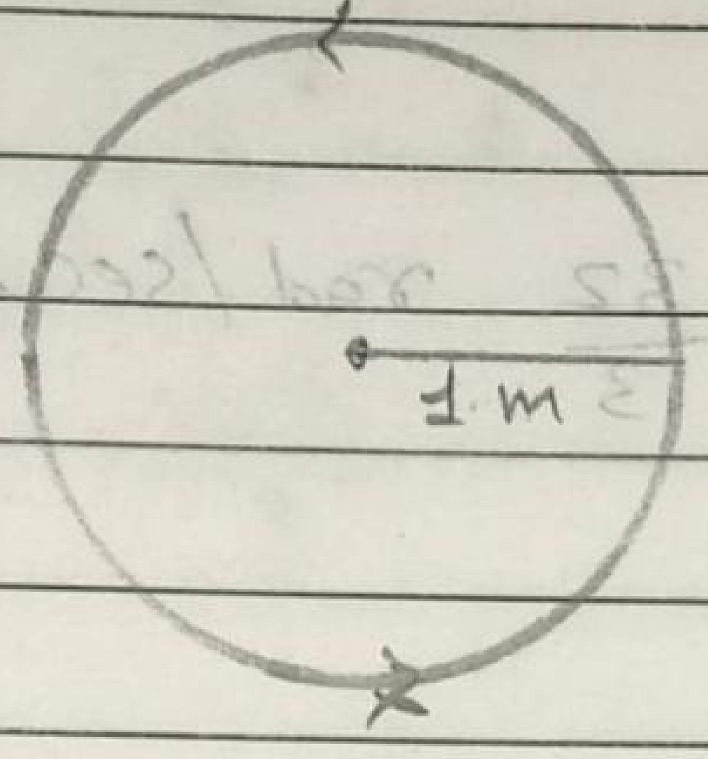
Q.



$a_{net} =$



Q.



$\alpha = f(t)$

$\alpha = 4t^2$

$\omega_i = 0$ rad./sec.

find the value of anet after 2 sec.

Ans. $a_{net} = \sqrt{a_r^2 + a_t^2}$

$a_r = \omega^2 R$ or $\frac{v^2}{R}$

$a_t = \alpha . R$ or $R . \frac{d\omega}{dt}$

$\Rightarrow a_t = \alpha . R$

$\Rightarrow a_t = 4t^2 . 1$

$\Rightarrow a_t = 4(2)^2 . 1$

$\Rightarrow a_t = 16 \ m/s^2$

$\Rightarrow a_r = \omega^2 R$

$\Rightarrow \alpha = \frac{d\omega}{dt} = \cancel{4}$

$\Rightarrow \frac{d\omega}{dt} = 4t^2$

$\Rightarrow d\omega = 4t^2 . dt$

Integrating,

$$\Rightarrow \int_0^{\omega} d\omega = \int_0^2 4t^2 . dt$$

$$\Rightarrow \omega = 4\left[\frac{t^3}{3}\right]_0^2$$

$$\Rightarrow \omega = 4 \times \frac{8}{3} = \frac{32}{3} \text{ rad/sec.}$$

$$\Rightarrow a_r = \omega^2 R$$

$$a_r = \left(\frac{32}{3}\right)^2 . 1 = \frac{1024}{9}$$

Q. $\alpha = 2t^2$, $r = 1$ m, $t = 2$ sec.
find $a_{net} = ?$

Sol. $a_{net} = \sqrt{a_r^2 + a_t^2}$

$$\Rightarrow a_r = \omega^2 R \quad \text{or} \quad \frac{V^2}{R}$$

$$\Rightarrow a_t = \alpha . R \quad \text{or} \quad R . \frac{d\omega}{dt}$$

$$\Rightarrow a_t = \alpha . R$$

$$\Rightarrow \frac{d\omega}{dt} = 2t^2$$

$$\Rightarrow \int_0^{\omega} d\omega = \int_0^2 2t^2 . dt$$

$$\Rightarrow \quad \omega = 2\left[\frac{t^3}{3}\right]_0^2$$

$$\Rightarrow \quad \omega = 2 \times \frac{8}{3} = \frac{16}{3} \text{ rad./sec.}$$

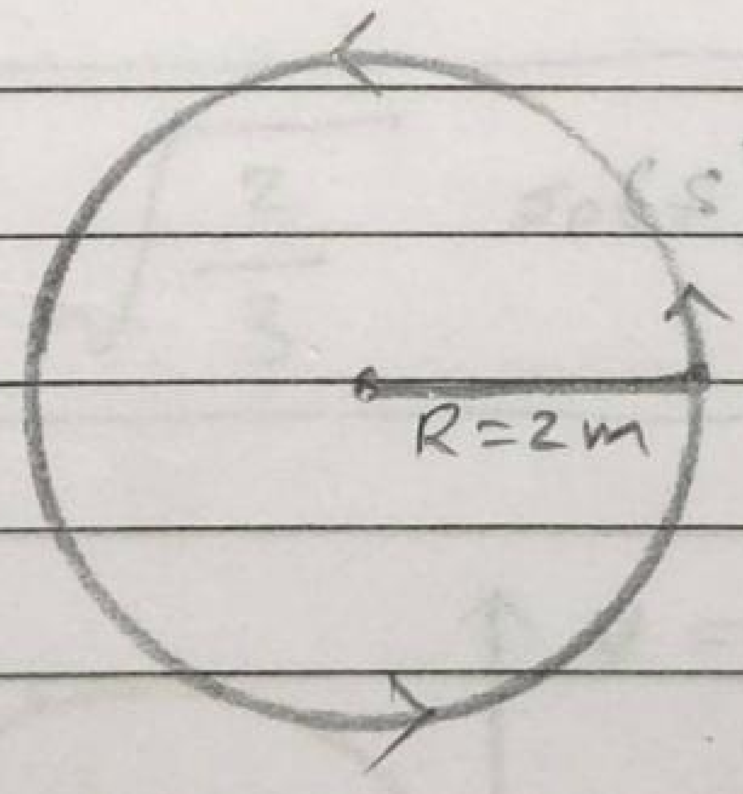
$$\Rightarrow \quad a_r = \omega^2 R$$

$$\Rightarrow \quad a_r = \left(\frac{16}{3}\right)^2 \cdot 1$$

$$\Rightarrow \quad a_r = \frac{256}{9}$$

Q. find the angle b/w a_r and a_{net} after 2 sec.

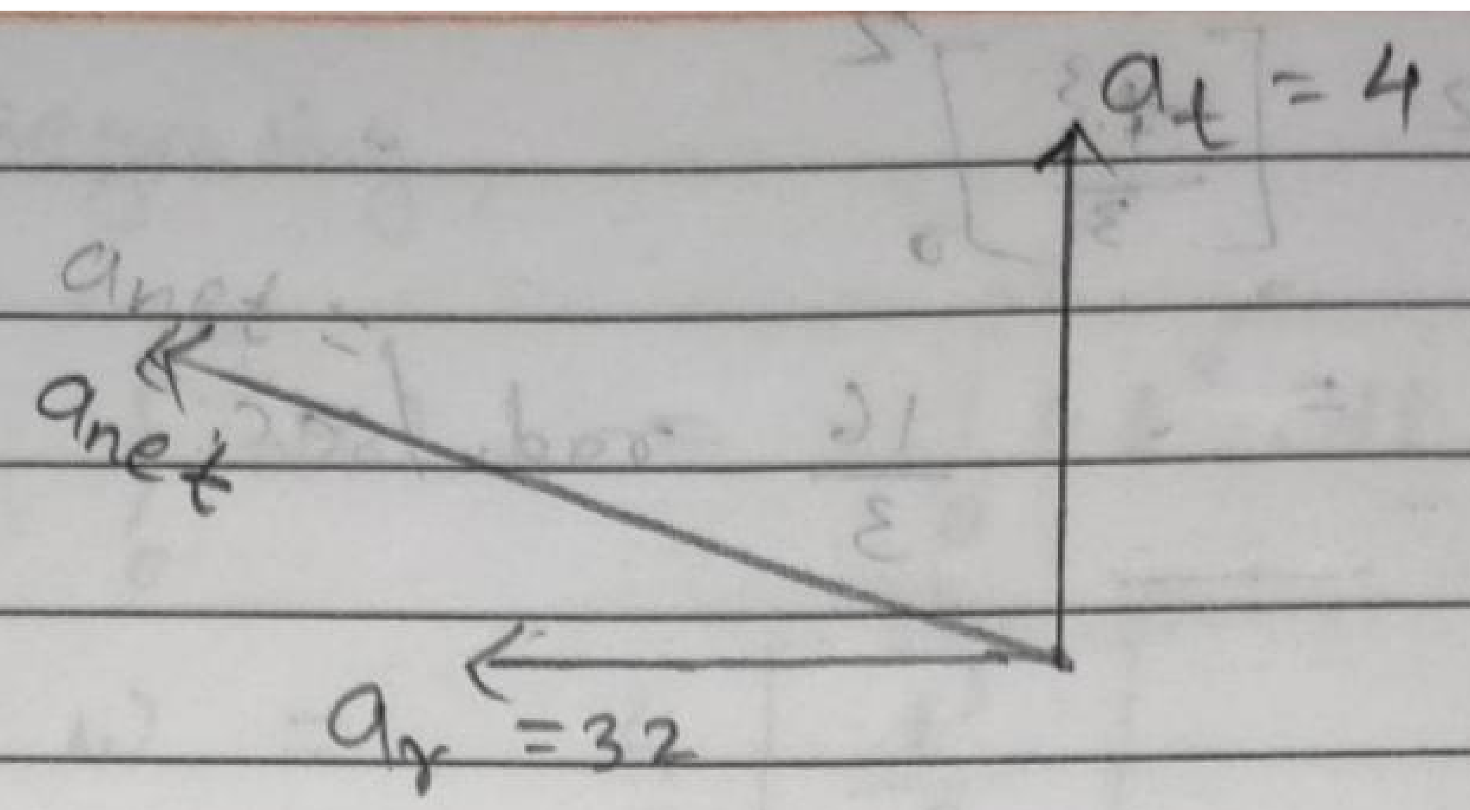
$\boxed{\omega = 2t}$ $\boxed{\omega_i = 0 \text{ rad./sec.}}$, $t = 2\text{sec.}$



Ans.

$$a_r = \omega^2 R$$
$$a_r = (2t)^2 \cdot 2$$
$$a_r = 4t^2 \cdot 2$$
$$a_r = 8t^2$$
$$a_r = 8 \times (2)^2$$
$$a_r = 32$$

$$a_t = \alpha . R.$$
$$\omega = 2t$$
$$\alpha = \frac{d\omega}{dt}$$
$$\alpha = \frac{d}{dt}(2t)$$
$$\boxed{\alpha = 2}$$



$\tan\theta = \frac{4}{32}$

$\tan\theta = \frac{1}{8}$

$\theta = \tan^{-1}\frac{1}{8}$

Q.7 $\omega = 2t$, particle is performing circular motion radius of 2m find time 't' when angle b/w a_r and a_{net} is 37°

Ans. $\Rightarrow a_r = \omega^2 \cdot R$

$\Rightarrow a_r = (2t)^2 \cdot (2)$

$\Rightarrow \boxed{a_r = 8t^2}$

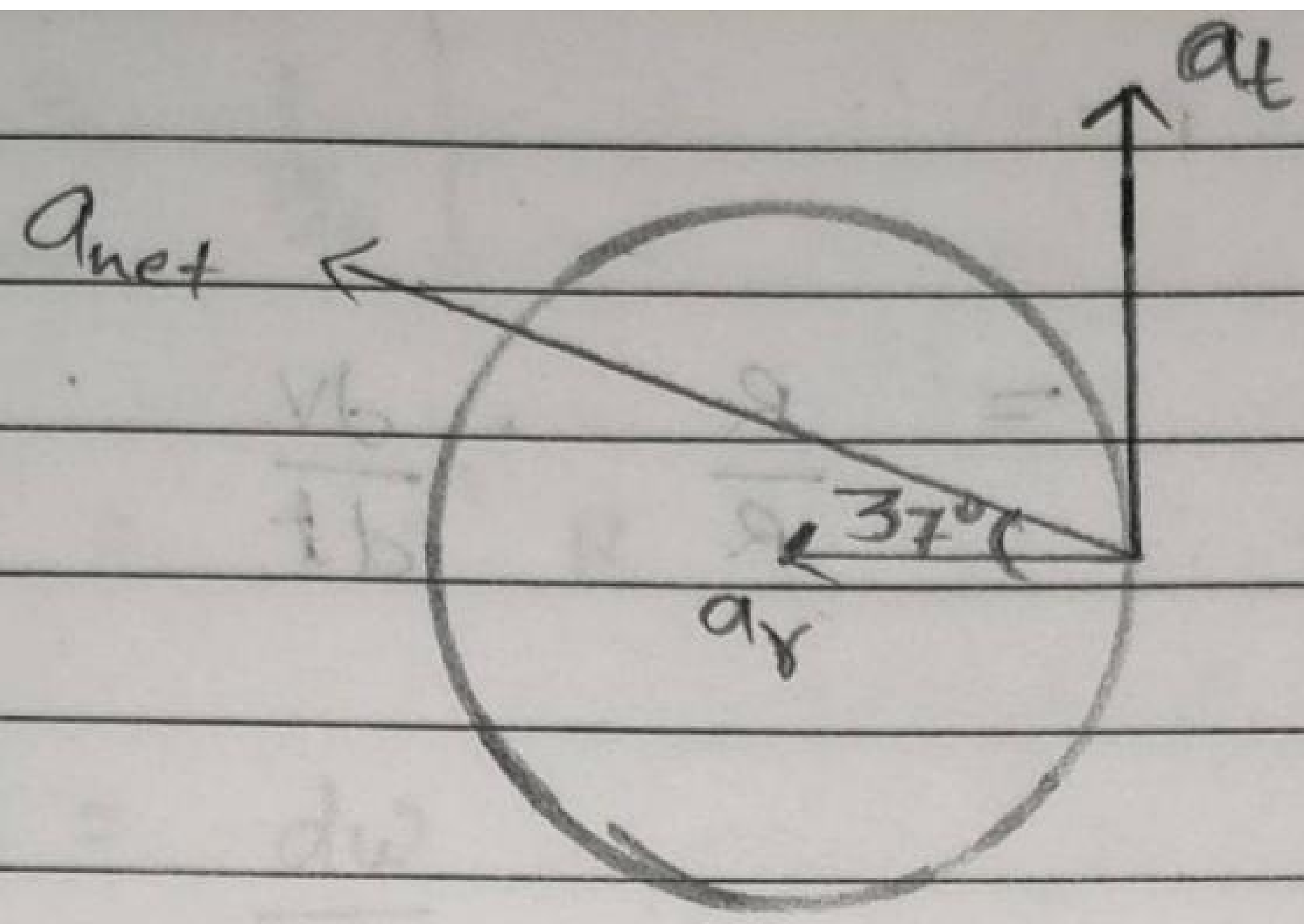
$\Rightarrow a_t = \alpha \cdot R$

$\Rightarrow \frac{d\omega}{dt} = \alpha = 2$

$\boxed{\alpha = 2}$

$\Rightarrow a_t = 2 \cdot 2$

$\Rightarrow \boxed{a_t = 4}$



$$\tan\theta = \frac{a_t}{a_r}$$

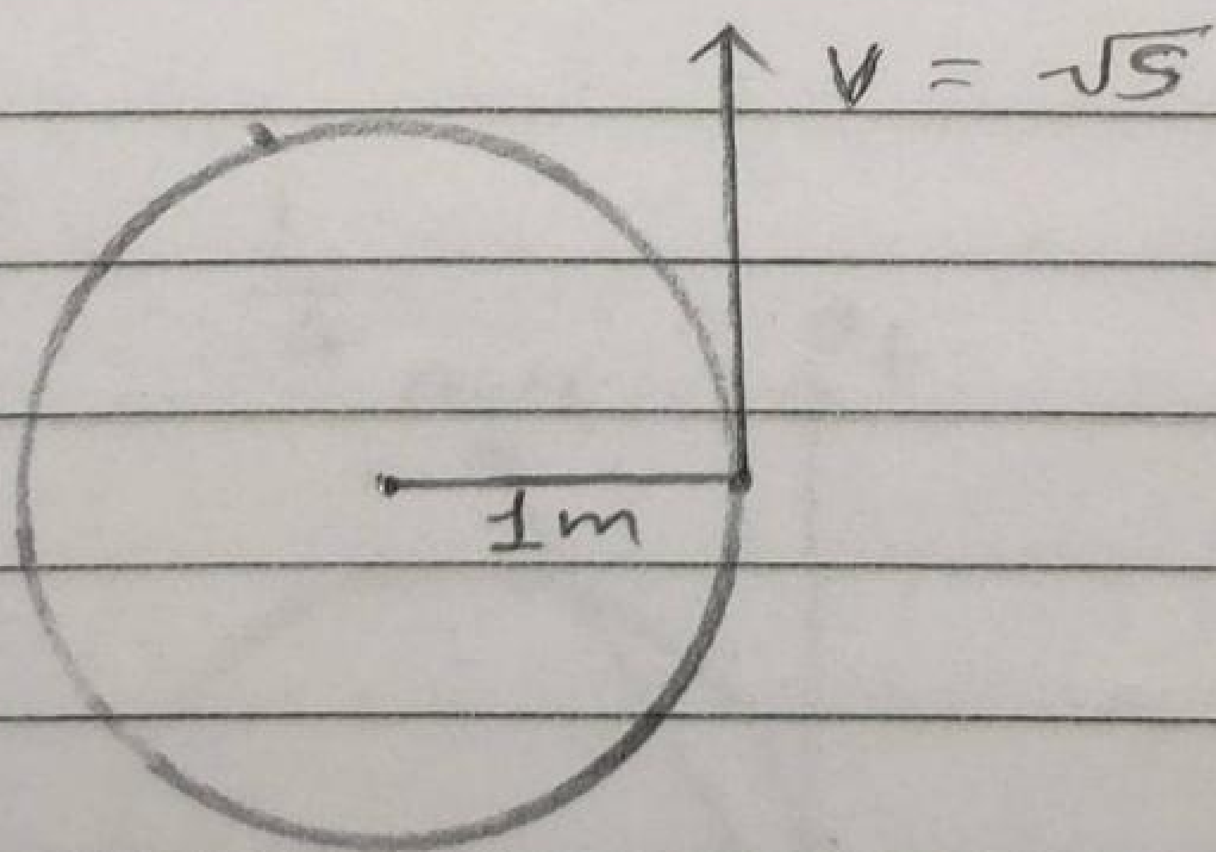
$$\Rightarrow \tan 37° = \frac{4}{8t^2}$$

$$\Rightarrow \frac{3}{4} = \frac{4}{8t^2}$$

$$\Rightarrow \cancel{8}t^2 = \frac{\cancel{16}\,2}{3}$$

$$\Rightarrow \boxed{t = \sqrt{\frac{2}{3}}\ \text{sec.}}$$

Q.)



find θ b/w a_r and a_{net} in 1 sec.

Sol.
$$a_r = \omega^2 . R$$
$$a_r = \frac{v^2}{R^{\cancel{2}}} . R = \frac{v^2}{R}$$

$$a_t = \alpha R$$

$$= R\frac{d\omega}{dt} = \frac{R}{R} \cdot \frac{dv}{dt}$$

$$\boxed{a_t = \frac{dv}{dt}}$$

$$\Rightarrow \quad a_t = v\frac{dv}{ds}$$

$$\Rightarrow \quad a_t = v\frac{d(\sqrt{s})}{ds}$$

$$\Rightarrow \quad a_t = \sqrt{s} \cdot \frac{1}{2\sqrt{s}}$$

$$\Rightarrow \quad \boxed{a_t = \frac{1}{2}}$$

$$\cancel{\alpha . R = a_t}$$

$$\Rightarrow \quad a_t = \alpha . R$$

$$\Rightarrow \quad \alpha . R = \frac{1}{2}$$

$$\Rightarrow \quad \alpha . 1 = \frac{1}{2}$$

$\Rightarrow \boxed{\alpha = \frac{1}{2}}$

$\Rightarrow a_r = \omega^2 R$

$\Rightarrow \alpha = \frac{d\omega}{dt}$

$\Rightarrow \frac{d\omega}{dt} = \frac{1}{2}$

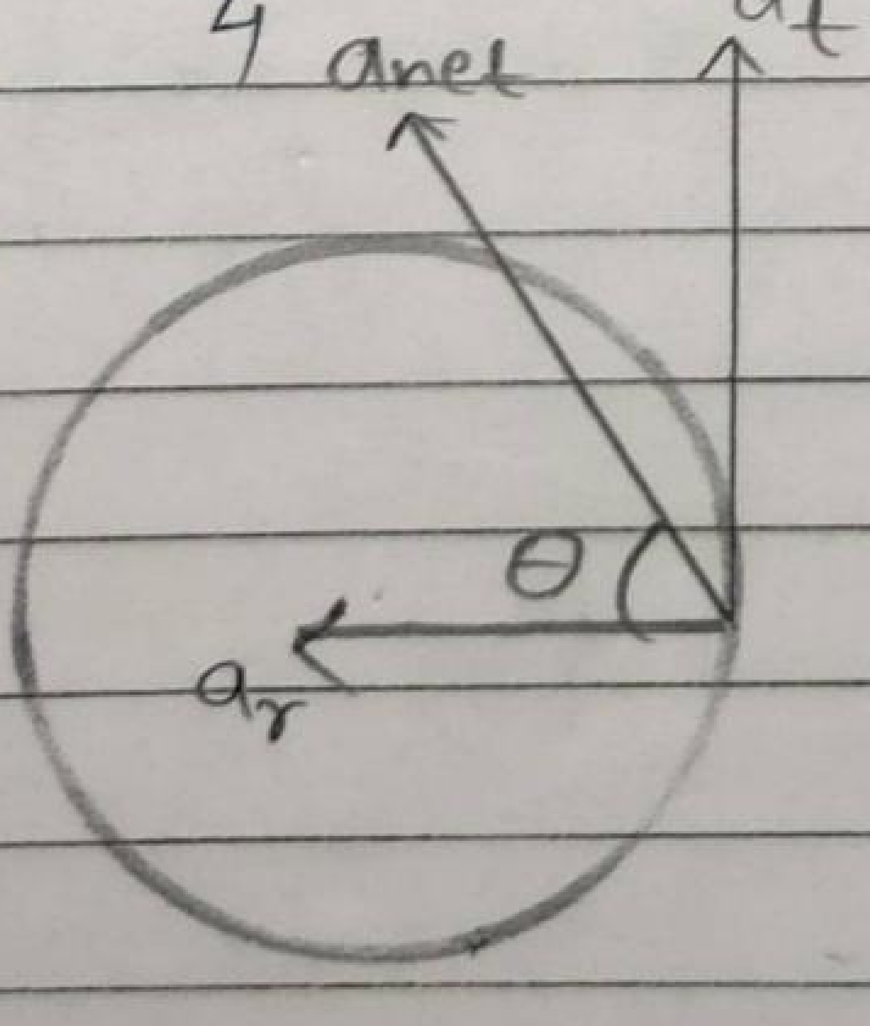
$\Rightarrow \int_0^{\omega} d\omega = \int_0^{1} \frac{1}{2} dt$

$\Rightarrow \omega = \frac{1}{2} \cdot 1$

$\Rightarrow \boxed{\omega = \frac{1}{2}}$

$\Rightarrow a_r = \left(\frac{1}{2}\right)^2 \cdot (1)$

$\Rightarrow a_r = \frac{1}{4}$



$\tan\theta = \frac{\frac{1}{2}}{\frac{1}{4}}$

$\tan\theta = 2$

$\boxed{\theta = \tan^{-1} 2}$

Q. ~~circular motion~~, a particle is performing circular motion Radius = 'r' whose centrepetal acceleration is given as $a_c = k r t^2$ find the value of

i) speed of this particle.

Sol. $a_c = \frac{v^2}{r}$

$k r t^2 = \frac{v^2}{r}$

$k r^2 t^2 = v^2$

$\boxed{v = \sqrt{k} \cdot r \cdot t}$

ii) $a_t = ?$

Sol. $a_t = \frac{dv}{dt}$

$a_t = \frac{d}{dt}(\sqrt{k} \cdot r \cdot t)$

$a_t = \sqrt{k} \cdot r \cdot 1$

$\boxed{a_t = \sqrt{k} \cdot r}$

Linear Variable | Angular Variable

	Linear Variable	Angular Variable
i)	$\vec{r}$ or $\vec{S}$	$\rightarrow \theta$
ii)	$\vec{V}$	$\rightarrow \omega$
iii)	$\vec{a}$	$\rightarrow \alpha$
iv)	t	

* initial angular velocity = ω_0 / ω_i
* final angular velocity = ω / ω_f

① $v = u + at$

$\omega = \omega_0 + \alpha t$

② $v^2 - u^2 = 2aS$

$\omega^2 - \omega_0^2 = 2\alpha\theta$ —— α = constant

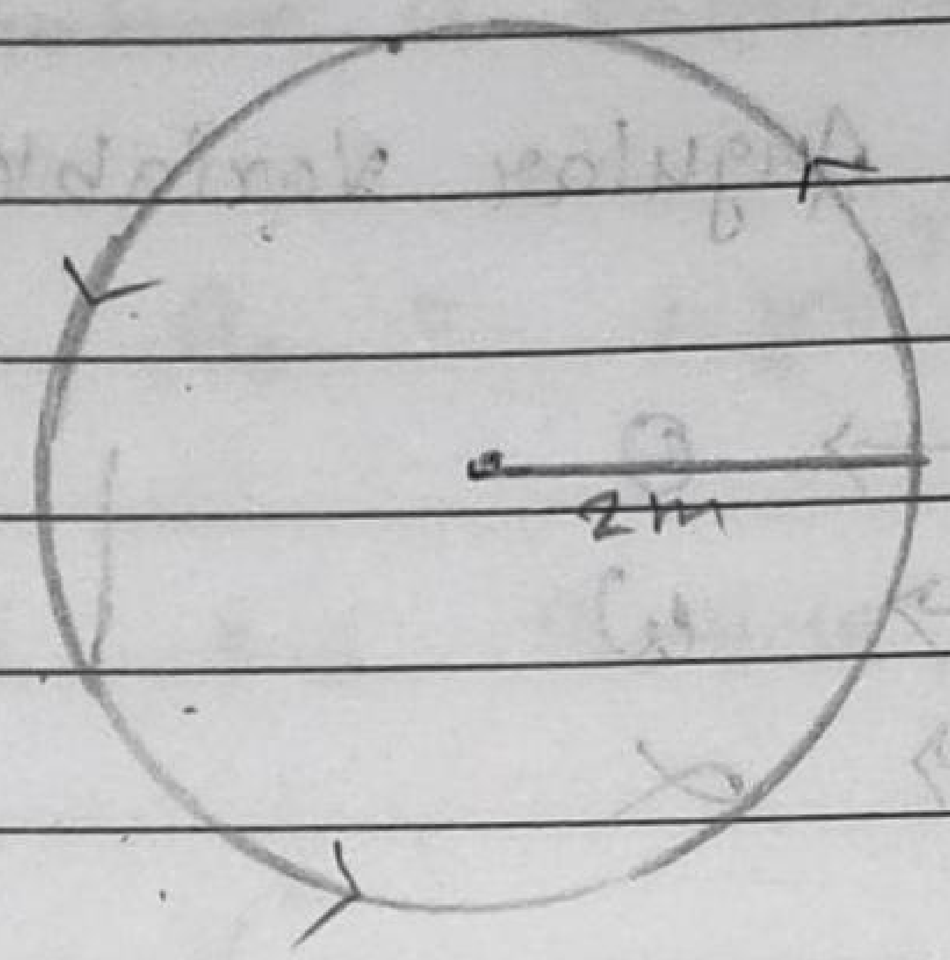
③ $S = ut + \frac{1}{2}at^2$

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

4) $S = \left(\frac{u+v}{2}\right)t$

$\theta = \left(\frac{\omega_0 + \omega}{2}\right)t$

Q.



$\omega_1 = 0$ rad/sec.

$a_t = 2\,m/s^2$

find the time taken by the particle to acheive angular velocity of 4 rad./sec.

Ans

$\omega_0 = 0$

$t = ?$

$\omega = 4$

$\alpha = ?$

$\Rightarrow \omega = \omega_0 + \alpha t$

$\Rightarrow a_t = \alpha R$

$\Rightarrow 2 = \alpha . 2$

$\Rightarrow \alpha = 1$ rad/sec^2

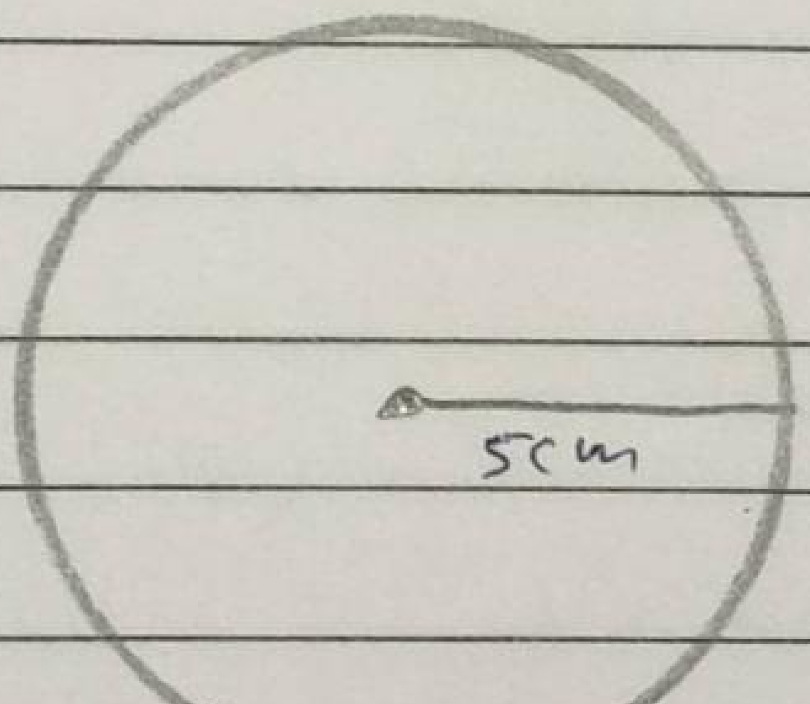
Q. a Particle is performing circular motion of radius 5 cm whose tendencial acceleration is $2 \, m/s^2$. particle angular velocity increases from 10 rad./sec to 20 rad./sec. during some time interval. Find out the time taken for this angular velocity to acheive and no. of revolution completed by this time.

Ans - $r = 5 \, cm$, $\omega_i = 10$ rad/s.
$t = ?$, $\omega_f = 20$ rad/s.

$\Rightarrow a_t = \alpha R$

$\Rightarrow 2 = \alpha . 5 \times 10^{-2}$

$\Rightarrow \alpha = \frac{2}{5} \times 10^{2} \, \cancel{rad./sec^2} = 40 \, rad/sec^2$



$\Rightarrow \omega = \omega_0 + \alpha t$

$\Rightarrow 20 = 10 + 40 \times t$

$\Rightarrow t = \frac{10}{40}$

$\Rightarrow \boxed{t = \frac{1}{4} \, sec.}$

$\Rightarrow \theta = \omega_0 t + \frac{1}{2} \alpha t^2$

$\Rightarrow \theta = 10 \times \frac{1}{4} + \frac{1}{2} \times 40 \times \frac{1}{4} \times \frac{1}{4}$

$\Rightarrow \theta = \frac{5}{2} + \frac{5}{4}$

$\Rightarrow \theta = \frac{15}{4}$ rad.

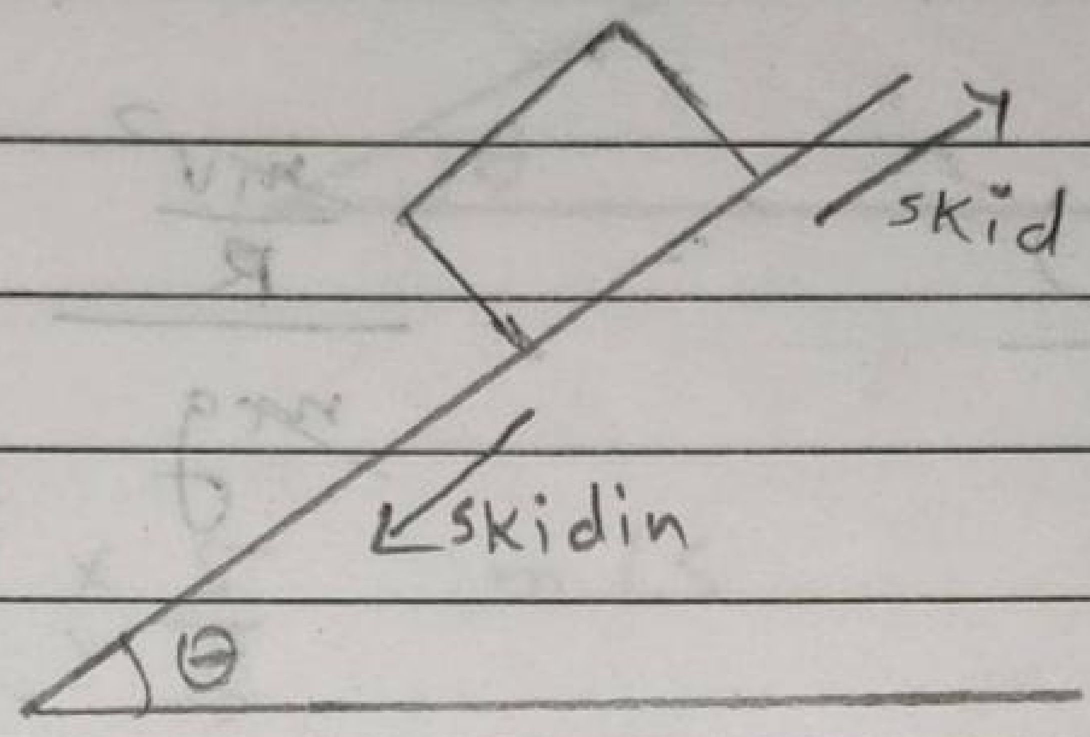
$\Rightarrow 2\pi = 1$ revolution.

$\Rightarrow \frac{15}{4}^{c} = \frac{1}{2\pi} \times \frac{15}{4}$

$\Rightarrow \frac{15}{4}^{c} = \frac{1}{2 \times 3.14} \times \frac{15}{4}$

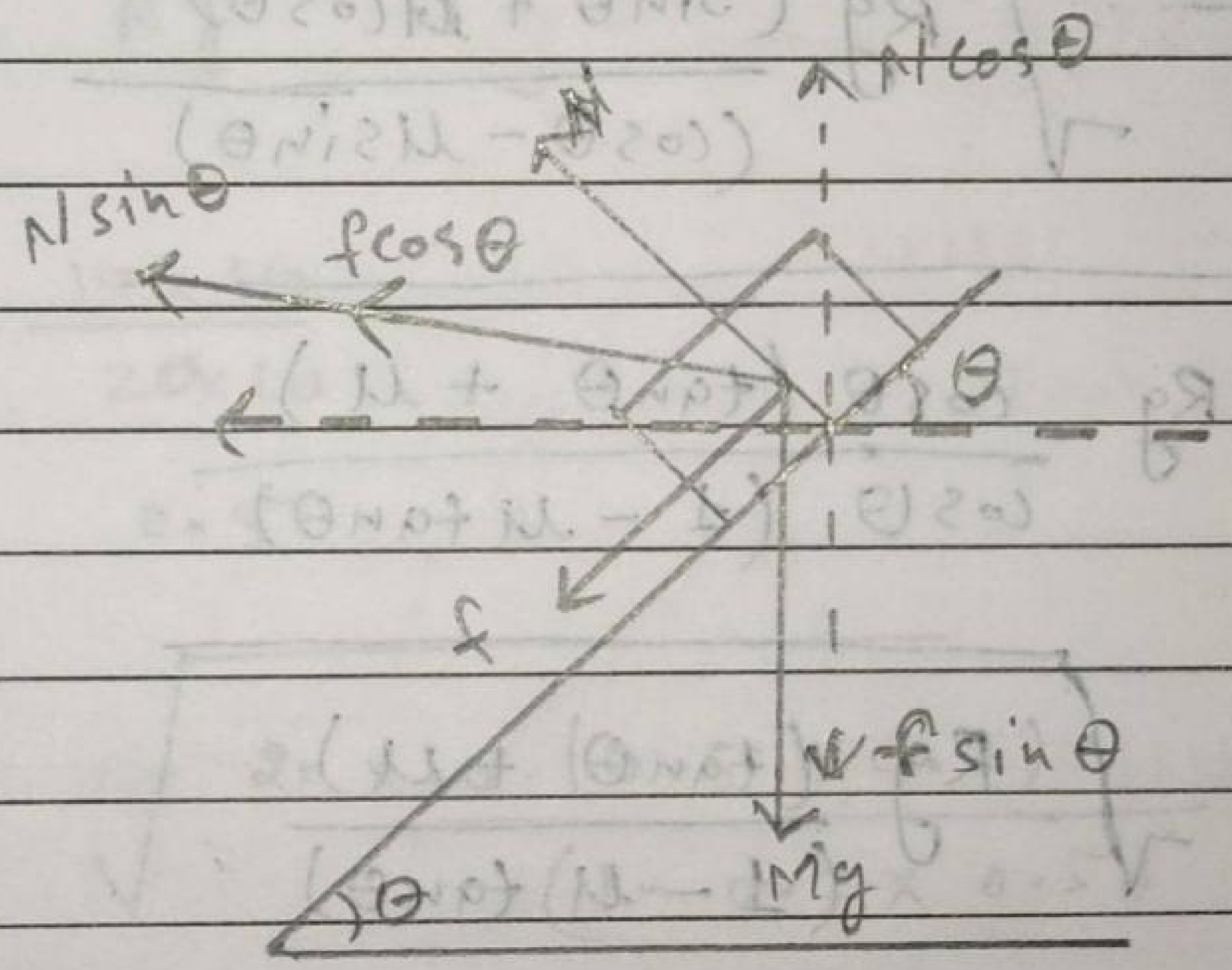
$\Rightarrow \frac{15}{4}^{c} = 3.2$

b) Banking of road with friction :-



maximum velocity with which vehicle can take a turn so, it does not skid out.

Ans:



$\Rightarrow$ $N\sin\theta + f\cos\theta = \frac{mv^2}{R}$

$\Rightarrow$ $N\cos\theta = mg + f\sin\theta$

$\boxed{f = \mu N}$

$N\sin\theta + \mu N\cos\theta = \frac{mv^2}{R}$ — (i)

$$N\cos\theta = mg + \mu N\sin\theta$$

$$N\cos\theta - \mu N\sin\theta = mg \quad \text{--- (2)}$$

$1 \div 2$

$$\Rightarrow \frac{\cancel{N}(\sin\theta + \mu\cos\theta)}{\cancel{N}(\cos\theta - \sin\theta)} = \frac{\frac{\cancel{m}v^2}{R}}{\cancel{m}g}$$

$$\Rightarrow \frac{v_{max}^2}{Rg} = \frac{\sin\theta + \mu\cos\theta}{\cos\theta - \mu\sin\theta}$$

$$\Rightarrow v_{max} = \sqrt{Rg\frac{(\sin\theta + \mu\cos\theta)}{(\cos\theta - \mu\sin\theta)}}$$

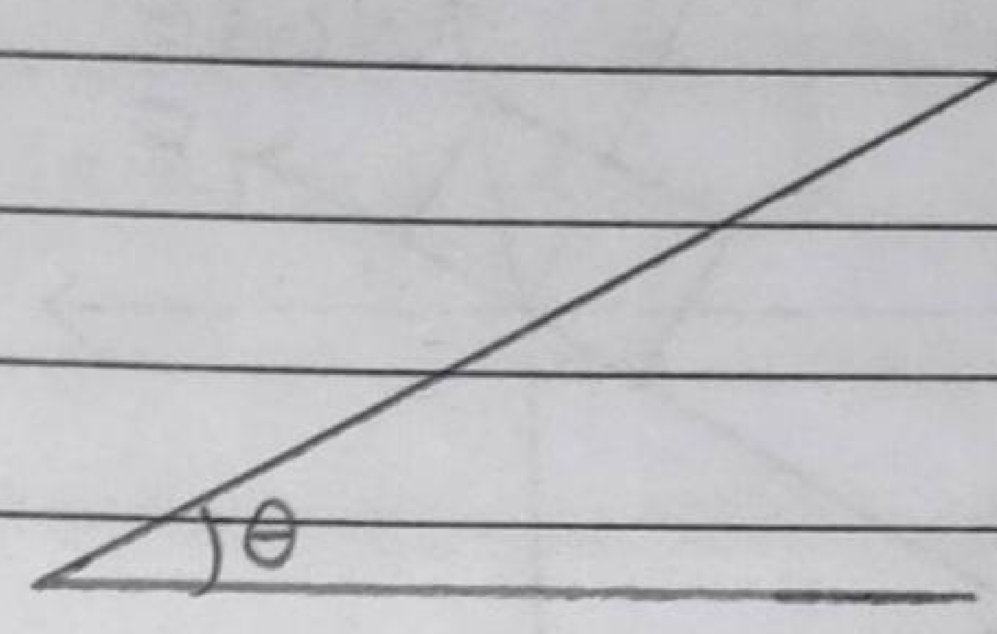
$$\Rightarrow v_{max} = \sqrt{Rg\frac{\cos\theta(\tan\theta + \mu)}{\cos\theta(1 - \mu\tan\theta)}}$$

$$\Rightarrow v_{max} = \sqrt{Rg\frac{(\tan\theta + \mu)}{(1 - \mu\tan\theta)}}$$

Q. The radius of a circular track is 20 m which is band for a safe turning ~~for a vehicle~~ of 36 KM/h if the coefficient of friction b/w the road and tier is 0.2 then find out the minimum and maximum speed at which vehicle can take a safe turn.

Ans.

$\mu = 0.2$



$\Rightarrow V = \cancel{36}^{2} \times \frac{5}{\cancel{18}_{1}}$ m/s

$\Rightarrow V = 10$ m/s

$\Rightarrow \tan\theta = \frac{v^2}{Rg}$

$\Rightarrow \tan\theta = \frac{10 \times 10}{20 \times 10}$

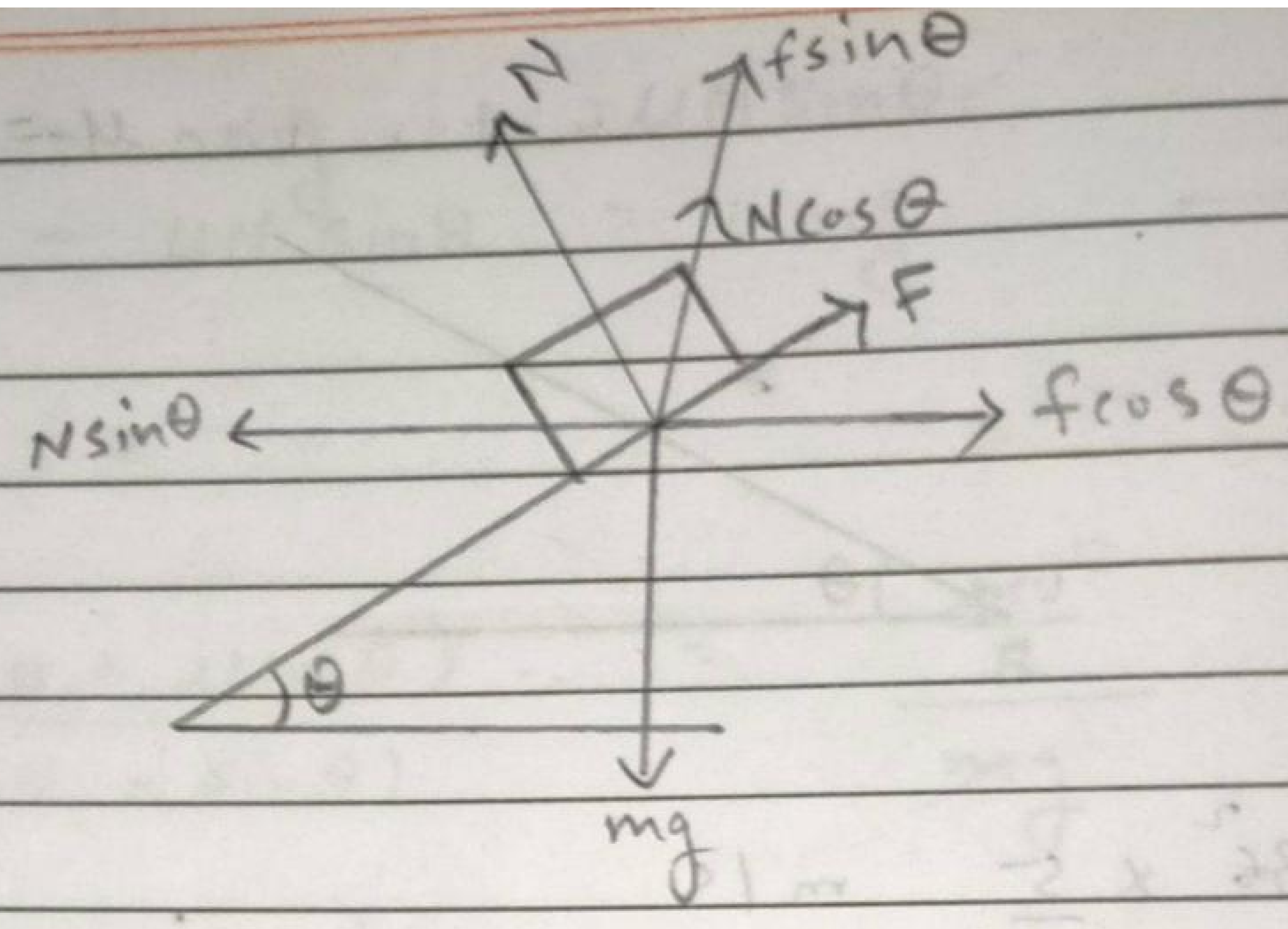
$\Rightarrow \tan\theta = 0.5$

$\Rightarrow V_{max} = \sqrt{\frac{20 \times 10 \,(0.5 + 0.2)}{(1 - 0.2 \times 0.5)}}$

$= \sqrt{\frac{200\,(0.7)}{(1 - 0.1)}}$

$= \sqrt{\frac{140}{0.9}}$

$V_{max} = 15$ m/s



$\Rightarrow \quad N\sin\theta - f\cos\theta = \dfrac{mv_{min}^2}{R}$

$\Rightarrow \quad N\cos\theta + f\sin\theta = mg$

$f = \mu N$

$\Rightarrow \quad N\sin\theta - \mu N\cos\theta = \dfrac{mv_{min}^2}{R}$ — (1)

$\Rightarrow \quad N\cos\theta + \mu N\sin\theta = mg$ — (2)

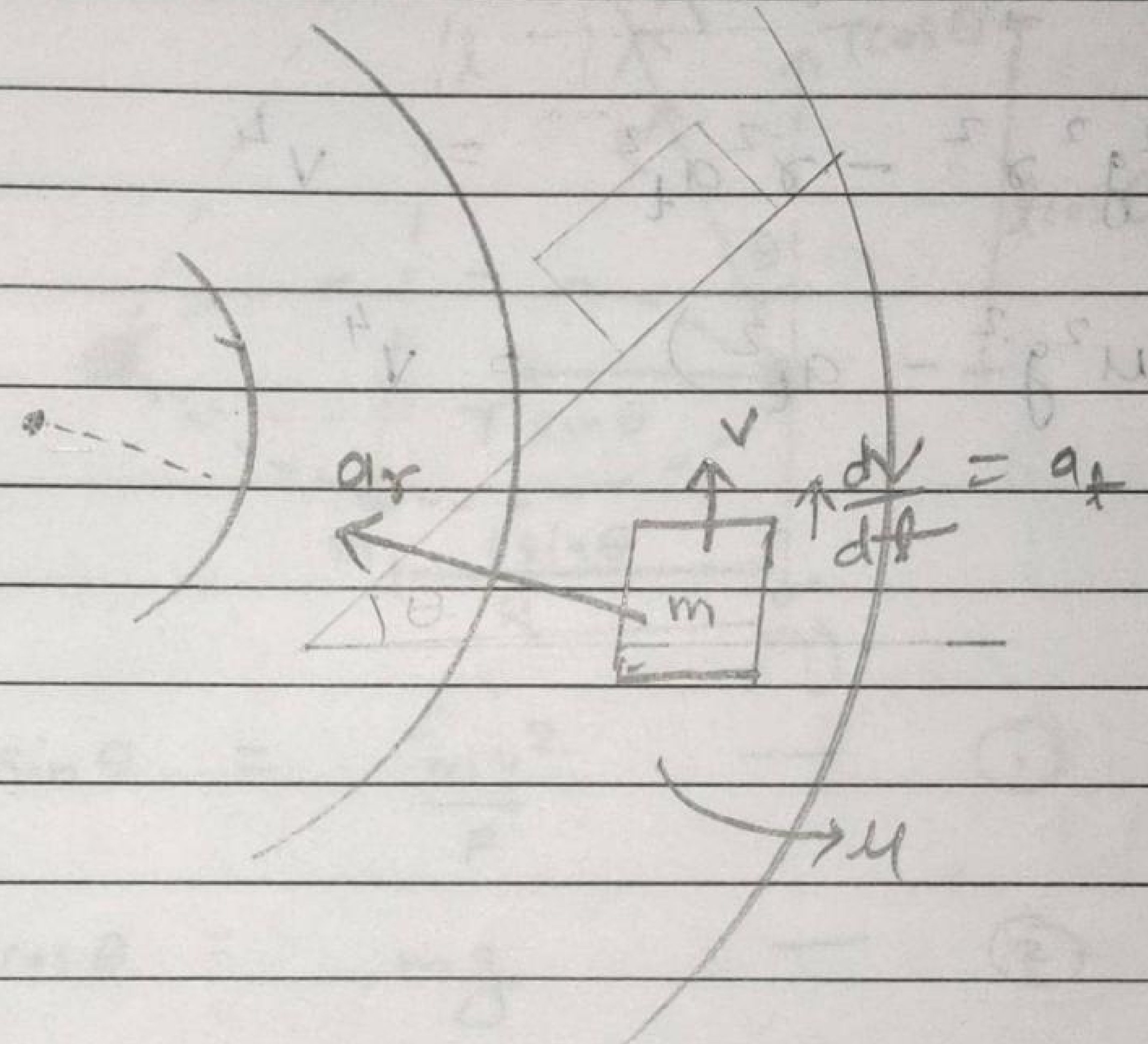
Solving (i) & (ii),

$$\Rightarrow V_{min} = \sqrt{Rg\frac{(\tan\theta - \mu)}{(1 + \mu\tan\theta)}}$$

$$\Rightarrow \frac{V_{max}}{V_{min}} = \frac{\sqrt{Rg\dfrac{(\tan\theta + \mu)}{(1 - \mu\tan\theta)}}}{\sqrt{Rg\dfrac{(\tan\theta - \mu)}{(1 + \mu\tan\theta)}}}$$

Q. a car is going through a circular track of radius R whose tangential acceleration is increasing, the cofficient friction b/w tier and road is μ. Find out the speed at which car can take a safe turn.

Ans.



$\Rightarrow a_{net} = \sqrt{a_r^2 + a_t^2}$

$\Rightarrow a_{net} = \sqrt{\left(\frac{v^2}{R}\right)^2 + a_t^2}$

$\Rightarrow F = m\, a_{net}$

$\Rightarrow f = m\, a_{net}$

$\Rightarrow \mu N = m\, a_{net}$

$\Rightarrow \mu \cancel{m} g = \cancel{m} \sqrt{\left(\frac{v^2}{R}\right)^2 + a_t^2}$

$\Rightarrow \mu^2 g^2 = \left(\frac{v^2}{R}\right)^2 + a_t^2$

$$\Rightarrow \mu^2 g^2 = \frac{v^4}{r^2} + \cancel{a} a_t^2$$

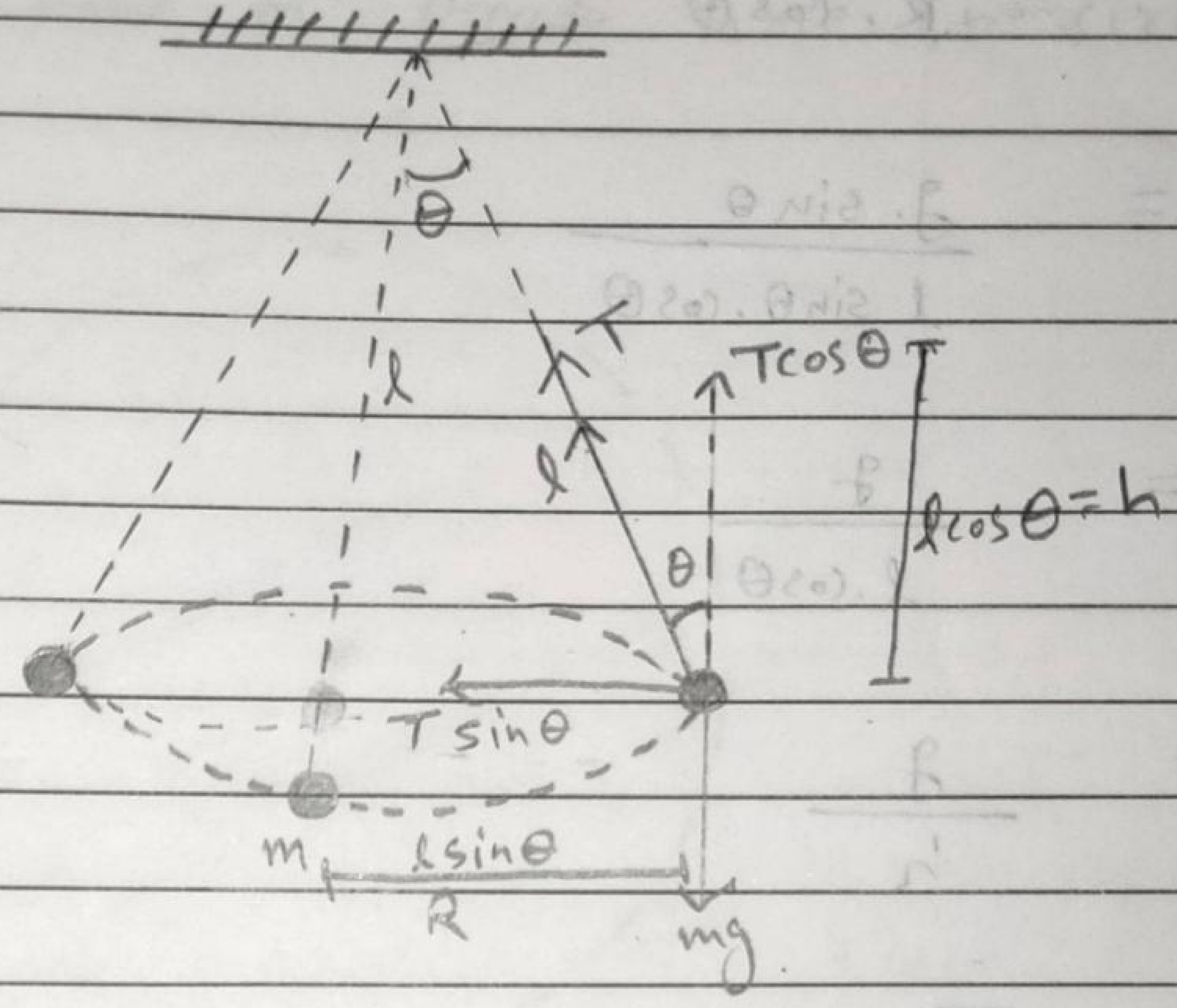
$$\Rightarrow \mu^2 g^2 = \frac{v^4 + r^2 a_t^2}{r^2}$$

$$\Rightarrow \cancel{r} \; \mu^2 g^2 r^2 - r^2 a_t^2 = v^4$$

$$\Rightarrow r^2 (\mu^2 g^2 - a_t^2) = v^4$$

$$\Rightarrow v^2 = r\sqrt{\mu^2 g^2 - a_t^2}$$ Ans.

Conical Pendulam :-



$$\Rightarrow \quad T\sin\theta = \frac{mv^2}{R} \quad \text{—} \quad (1)$$

$$\Rightarrow \quad T\cos\theta = mg \quad \text{—} \quad (2)$$

(2) ÷ (1)

$$\Rightarrow \quad \frac{T\cos\theta}{T\sin\theta} = \frac{mg}{\frac{mv^2}{R}}$$

$$\boxed{v = R\omega}$$

$$\Rightarrow \quad \frac{\cos\theta}{\sin\theta} = \frac{g}{\frac{R \cdot R \cdot \omega^2}{R}}$$

$$\Rightarrow \quad \frac{\cos\theta}{\sin\theta} = \frac{g}{R\omega^2}$$

$$\Rightarrow \omega^2 = \frac{g \cdot \sin\theta}{R \cdot \cos\theta}$$

$$\Rightarrow \omega^2 = \frac{g \cdot \sin\theta}{l \sin\theta \cdot \cos\theta}$$

$$\Rightarrow \omega^2 = \frac{g}{l \cdot \cos\theta}$$

$$\Rightarrow \omega^2 = \frac{g}{h}$$

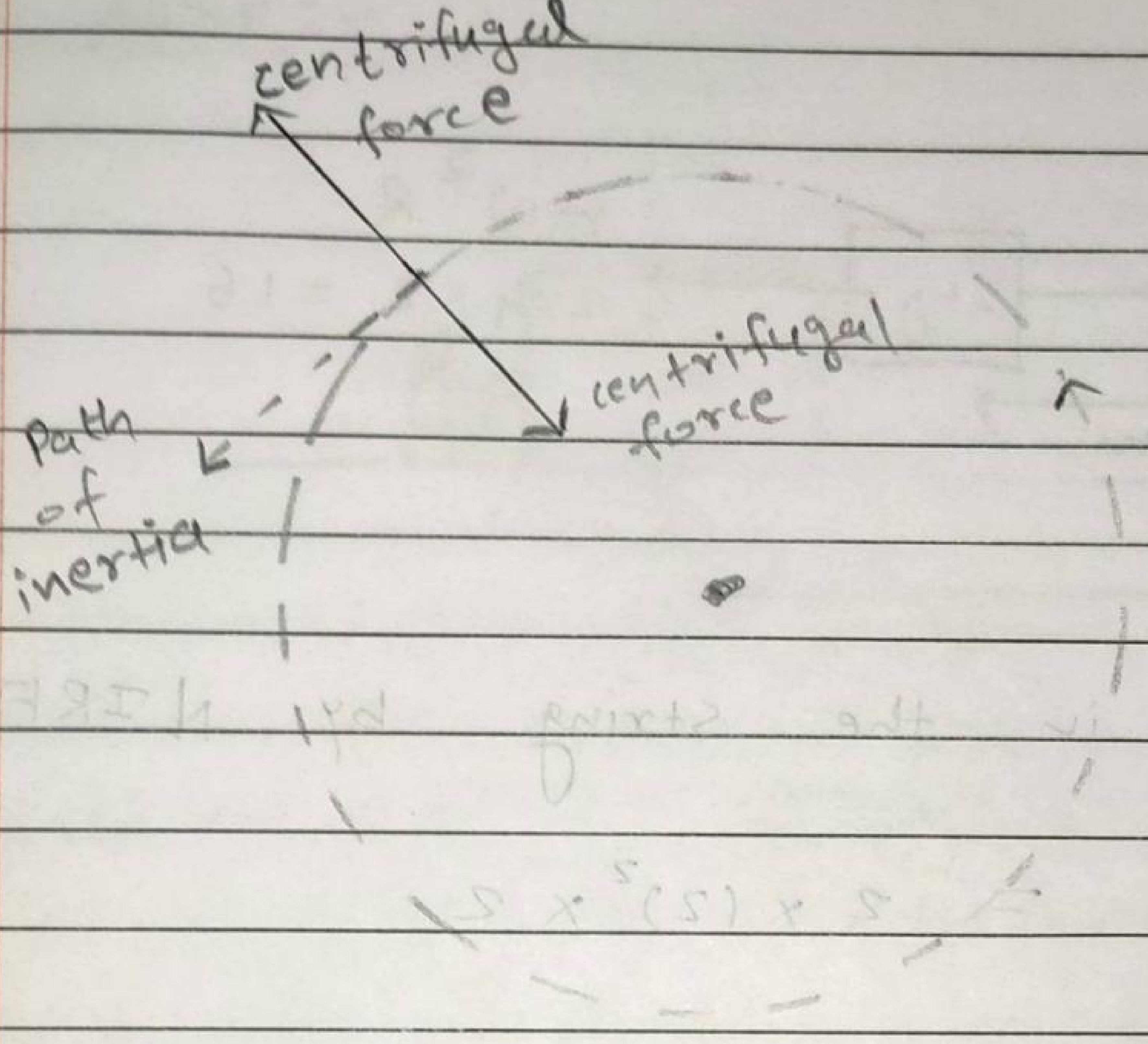
$$\Rightarrow \omega = \sqrt{\frac{g}{h}}$$

$$\Rightarrow T = \frac{2\pi}{\omega}$$

$$\Rightarrow \boxed{T = 2\pi\sqrt{\frac{h}{g}}}$$

~~Centripetal~~ centrifugal force :-

→ It's a name to pseudo force in circular motion.

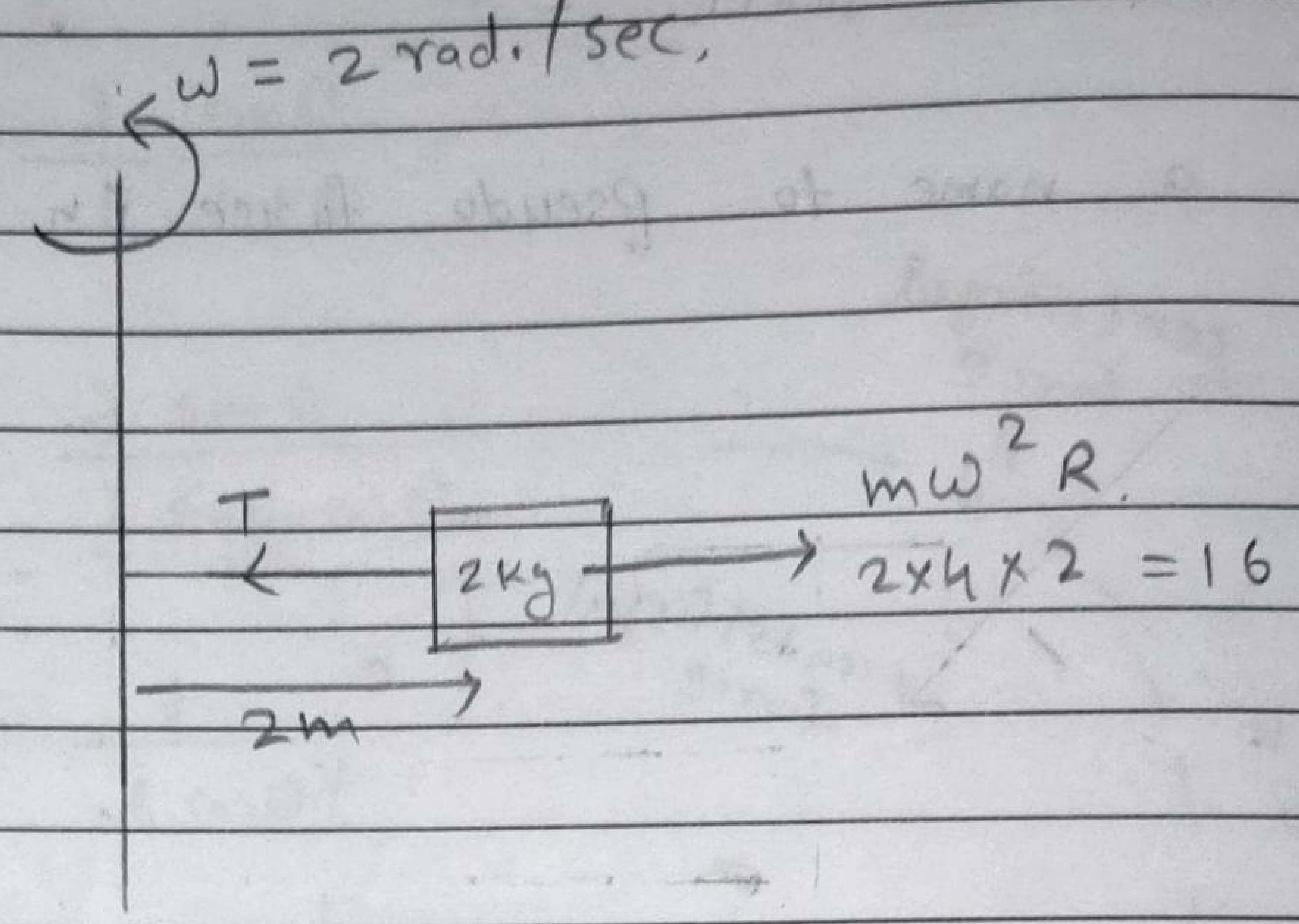


Centrifugal force, $F = \frac{mv^2}{r}$

$$F = \frac{m(\omega r)^2}{r}$$

$$\boxed{F = m\omega^2 r}$$

Q.



find Tension in the string by N IRF.

$\Rightarrow \quad T = m\omega^2 R = 2 \times (2)^2 \times 2$

$\Rightarrow \quad T = 16\ N$