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# PRAYAS

## JEE 2025

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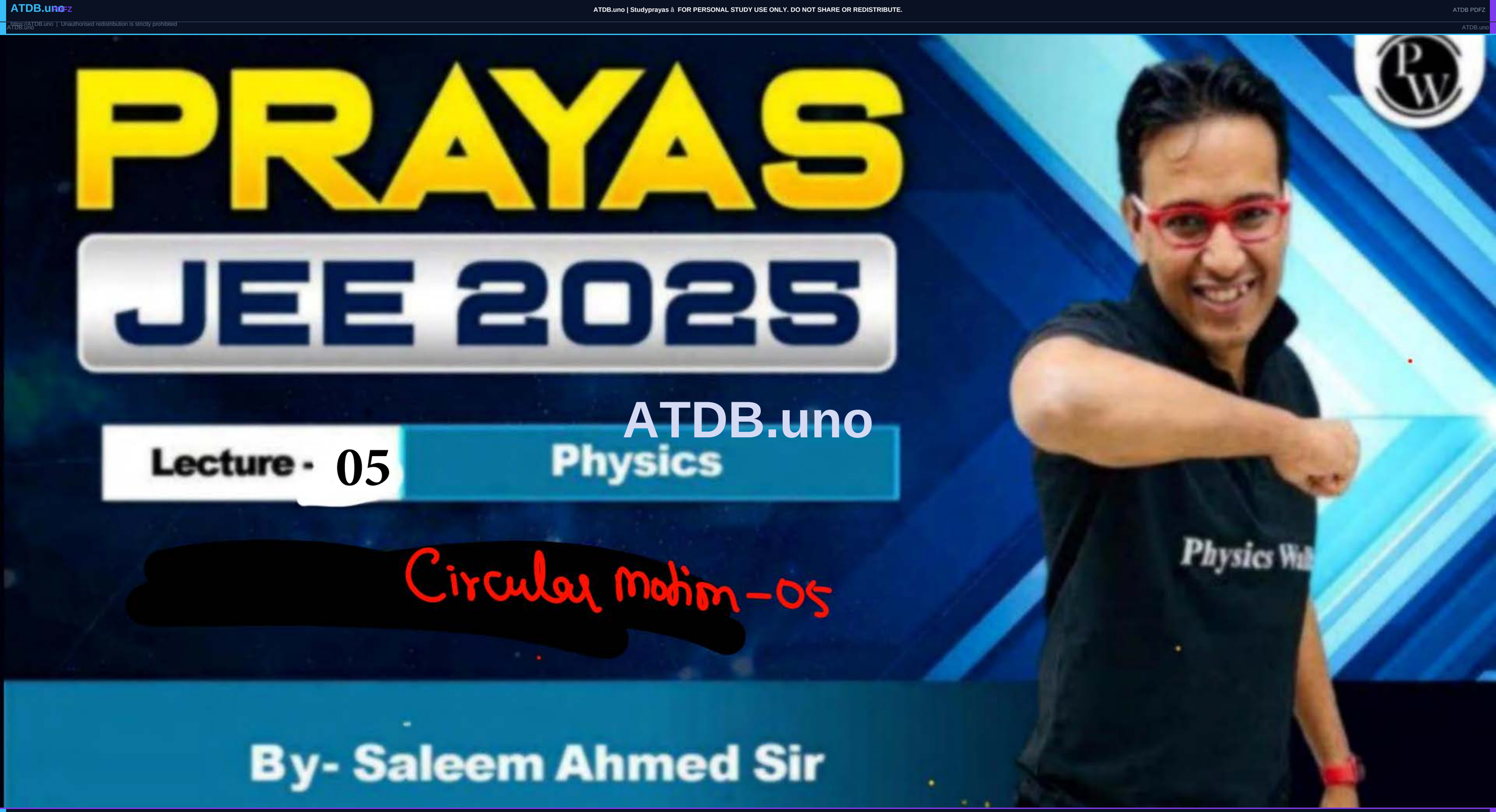
Lecture - 05

Physics

Circular Motion - 05




By- Saleem Ahmed Sir

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# Topics to be covered

1. Banking of road
2. H.W Discussion.
3.
4.

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Q Find the max speed that a vehicle can have moving in a circle of radius R with const speed v such that surface is horizontal and coff. of friction is $\mu$.

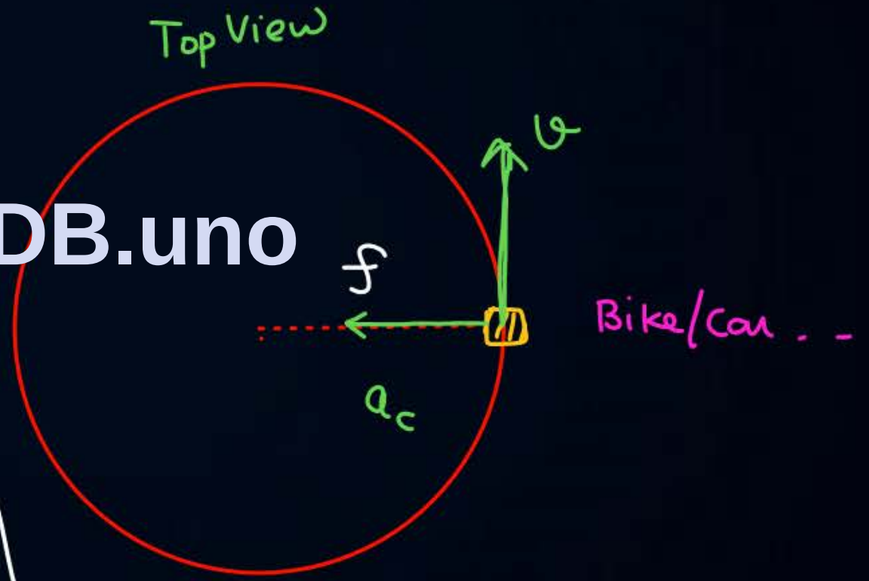
Sol

$$f = \frac{mv^2}{R}$$

max max

$$\mu_s mg = \frac{mv^2}{R}$$

$$\boxed{v = \sqrt{\mu_s R g} = v_{max}}$$

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A cyclist speeding at 18 km/h on a level road takes a sharp circular turn of radius 3 m without reducing the speed. The co-efficient of static- friction between the tyres and the road is 0.1. Will the cyclist slip while taking the turn? $v_{max}$ for safely turn = ?

एक सीधी सड़क पर 18 km/h की चाल से गतिशील एक साइकिल सवार अपनी चाल को कम किए बिना 3m त्रिज्या वाले एक तीक्ष्ण वृत्ताकार घुमाव पर मुड़ता है। टॉयरों तथा सड़क के मध्य स्थैतिक घर्षण गुणांक 0.1 है। क्या मुड़ने के दौरान साइकिल सवार फिसल जाएगा ?

yes फिसलेगा

$v = 18\ km/hr = 18 \times \frac{5}{18} = 5\ m/s$

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$R = 3$

$\mu_s = 0.1$

$v_{max} = \sqrt{\mu_s R g} = \sqrt{0.1 \times 3 \times 10} = 1.73$

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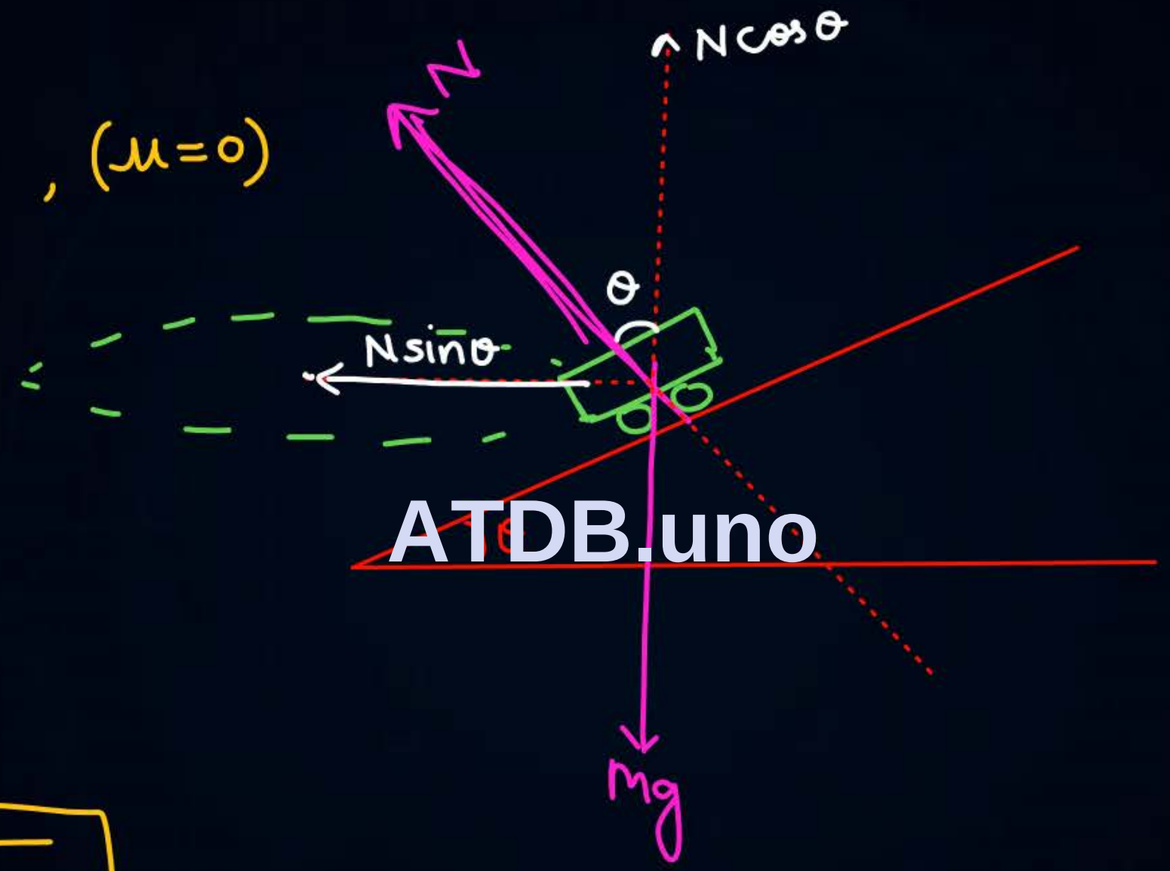
# Banking of road

① frictionless , $(\mu = 0)$

No friction




$$N\cos\theta = mg$$

$$N\sin\theta = \frac{mv^2}{R}$$

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

$$\boxed{v = \sqrt{Rg\tan\theta}}$$

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# friction वाली road

$$v_{max} = \sqrt{Rg\tan(\theta+\phi)}$$

$$\tan\phi = \mu_s$$

$$v_{min} = \sqrt{Rg\tan(\theta-\phi)}$$

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$$\sqrt{Rg\tan(\theta-\phi)} \leq v \leq \sqrt{Rg\tan(\theta+\phi)}$$

$v = \sqrt{Rg\tan\theta}$ ⇒ बिना friction के turn ✓

$f = 0$

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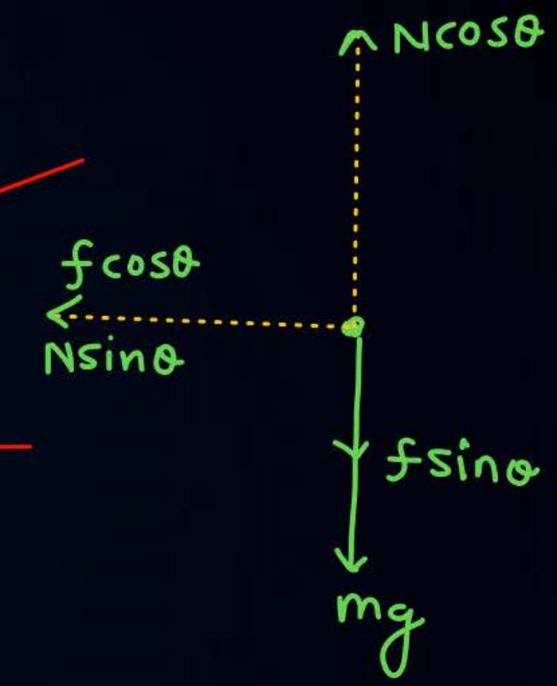
# for $V_{max}$

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

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

for $v_{max}$ $\quad f \longrightarrow (f_s)_{max}$

$$f = (f_s)_{max} = \mu_s N$$

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$$N\cos\theta - \mu_s N\sin\theta = mg$$

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

$$\Rightarrow v_{max} = \sqrt{Rg\tan(\theta+\phi)}$$

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

$$N\cos\theta - \mu_s N\sin\theta = mg$$

$$\mu_s = \tan\phi$$

$$\frac{\mu_s N\cos\theta + N\sin\theta}{N\cos\theta - \mu_s N\sin\theta} = \frac{v^2}{Rg}$$

$$\frac{\tan\phi + \tan\theta}{1 - \tan\phi\tan\theta} = \frac{v^2}{Rg} = \tan(\theta+\phi)$$

$$v_{max} = \sqrt{Rg\tan(\theta+\phi)}$$

$$\frac{\mu_s + \tan\theta}{1 - \mu_s\tan\theta} = \frac{v^2}{Rg}$$

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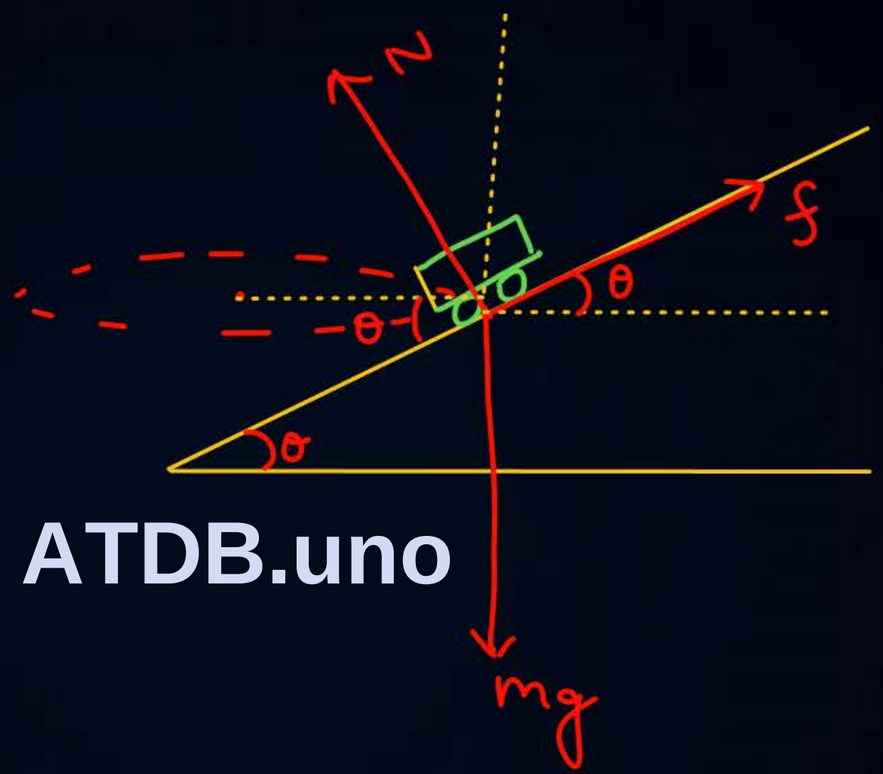
for $V_{min}$

$$v_{min} = \sqrt{Rg\tan(\theta - \phi)}$$

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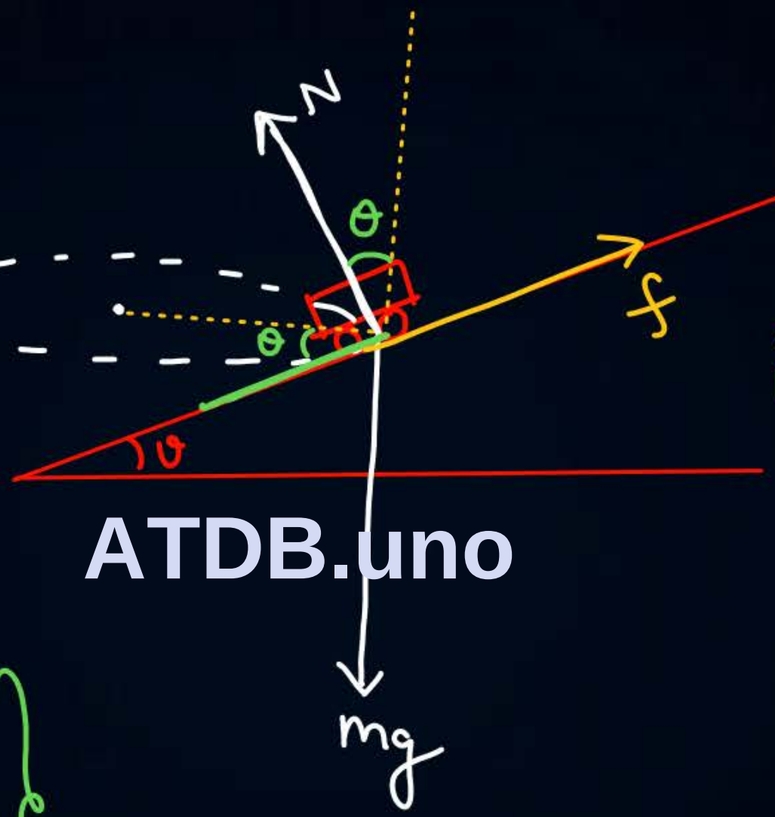
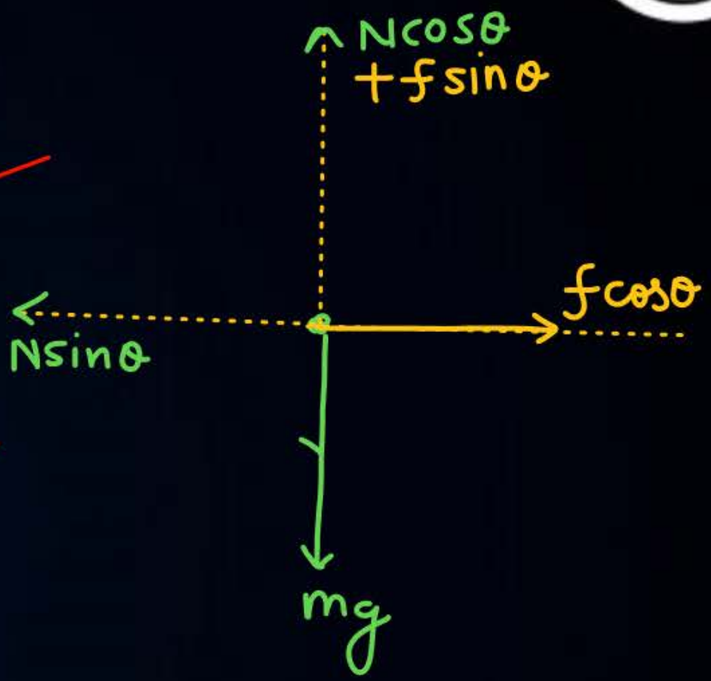
for $V_{min}$

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

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

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

$$-\mu_s N\cos\theta + N\sin\theta = \frac{mv^2}{R}$$

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$$-\mu_s N\cos\theta + N\sin\theta = \frac{mv^2}{R}$$

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

$$\mu_s = \tan\phi$$

$$\frac{-\tan\phi + \tan\theta}{1 + \tan\phi\tan\theta} = \frac{v^2}{Rg} = \tan(\theta - \phi)$$

$$\frac{-\mu_s N\cos\theta + N\sin\theta}{N\cos\theta + \mu_s N\sin\theta} = \frac{v^2}{Rg}$$

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$$v_{max} = \sqrt{Rg\tan(\theta - \phi)}$$

$$\frac{-\mu_s + \tan\theta}{1 + \mu_s\tan\theta} = \frac{v^2}{Rg}$$

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Q $R = 20m$, $\mu_s = \frac{1}{\sqrt{3}}$

$\tan\phi = \mu_s = \frac{1}{\sqrt{3}}$

$\phi = 30^\circ$

① find max possible speed for safely turn $= \sqrt{Rg\tan(\theta+\phi)} = \sqrt{20\times10\tan(45+30)}$

② find $v_{min}$ for safely turn $= \sqrt{20\times10\times\tan(45-30)}$

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③ At what speed friction is not required to turn safely.

$v = \sqrt{Rg\tan\theta} = \sqrt{20\times10\times\tan45^\circ} = 10\sqrt{2} = 14.2\,m/s$

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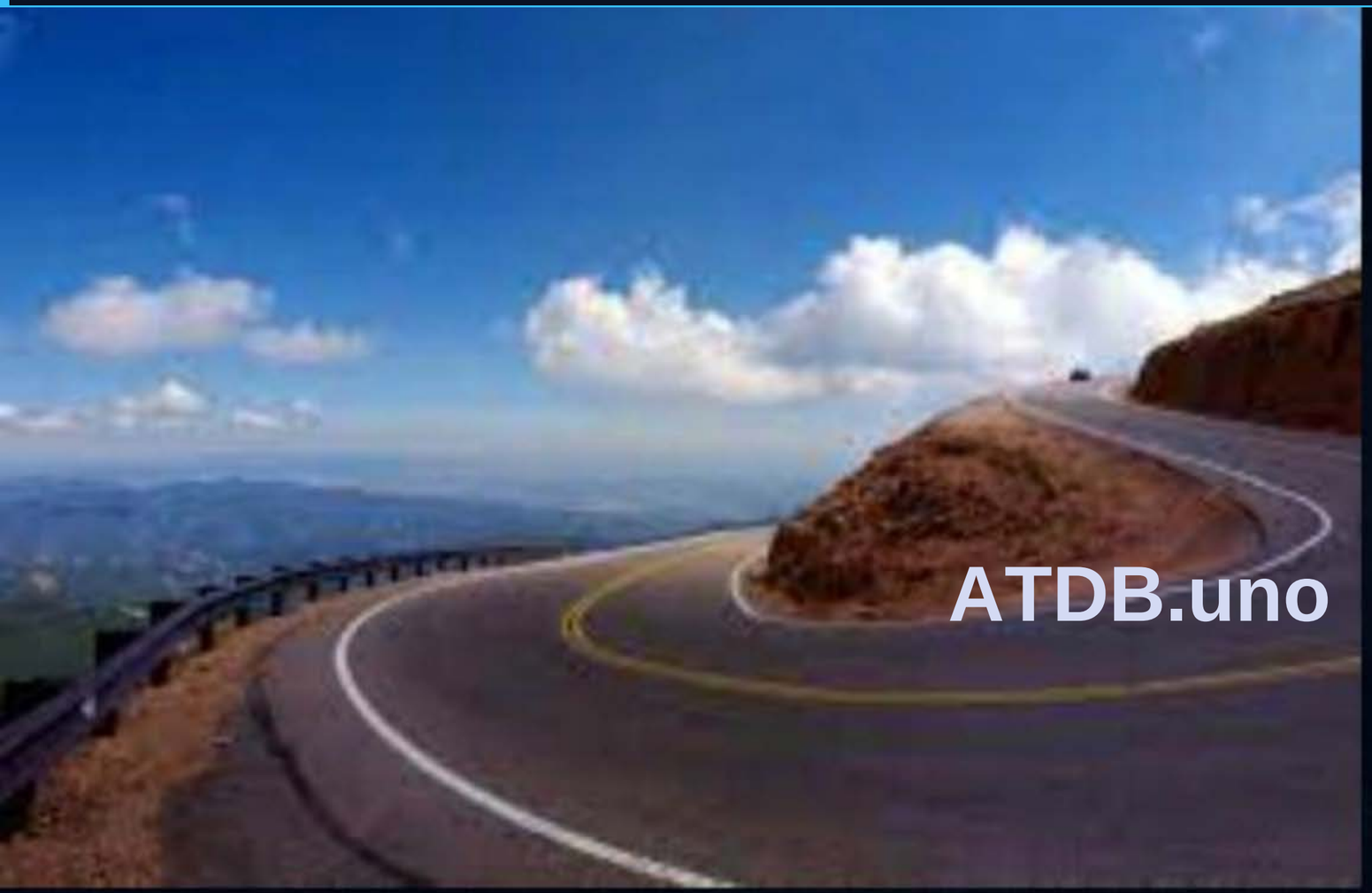


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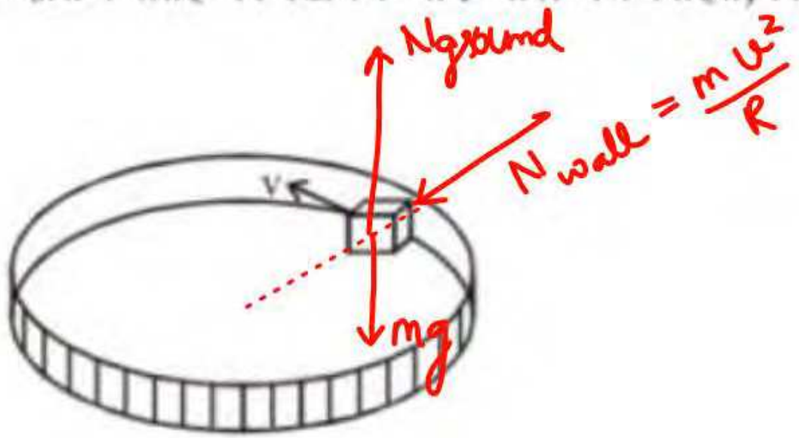
**11.** A block of mass m moves with speed v against a smooth, fixed vertical circular groove of radius r kept on smooth horizontal surface.

एक ब्लॉक का द्रव्यमान m है। यह चिकनी क्षैतिज सतह पर रखे त्रिज्या r वाले घर्षणरहित, स्थिर ऊर्ध्वाधर वृत्ताकार खाँचें में v चाल से गति करता है

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Find :

(i) normal reaction of the floor on the block.

(ii) normal reaction of the vertical wall on the block.

ज्ञात कीजिए :

(i) ब्लॉक पर फर्श की अभिलम्ब प्रतिक्रिया।

(ii) ब्लॉक पर ऊर्ध्वाधर दीवार की अभिलम्ब प्रतिक्रिया।

**Ans.** (i) mg, (ii) $\frac{mv^2}{r}$

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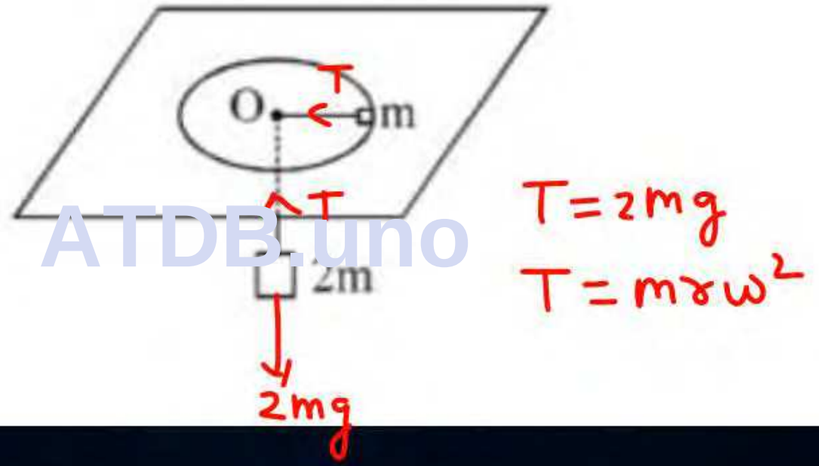
stationary mass 2m, attached to the other end of the string passing through smooth hole O in table, hanging vertically. Find the angular velocity of rotation.

एक घर्षणरहित चिकनी मेज पर एक द्रव्यमान m, 1 m त्रिज्या के क्षैतिज वृत्त में मुक्त रूप से घूर्णन कर रहा है। इस मेज पर एक घर्षणरहित छिद्र O है (चित्र देखें) इसमें से एक रस्सी गुजर रही है। इस रस्सी के एक सिरे पर द्रव्यमान m (जो कि घूर्णन कर रहा है) बंधा हुआ है तथा दूसरे सिरे पर द्रव्यमान 2m (जो कि ऊर्ध्वाधर रूप से लटका हुआ है) जुड़े हैं। घूर्णन का कोणीय वेग ज्ञात कीजिए।




$T = 2mg$

$T = mr\omega^2$

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**Ans.** $\sqrt{2g}$ rad/s

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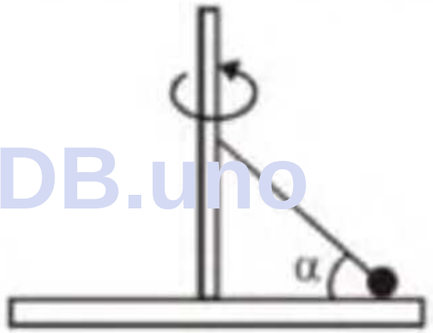
is a ball of mass 1 kg, attached to the long axis of the platform by a thin rod of length 10 cm ($\alpha = 30°$). Find normal force exerted by the ball on the platform (in newton). Friction is absent.

एक वृत्ताकार प्लेटफॉर्म, ऊर्ध्वाधर अक्ष के चारों ओर कोणीय वेग $\omega = 10$ rad/s से घूमता है। प्लेटफॉर्म पर एक 1 kg द्रव्यमान की गेंद रखी है जो 10 cm लम्बी पतली छड़ द्वारा प्लेटफॉर्म की लम्बी अक्ष से जुड़ी हुई है, तथा ($\alpha = 30°$) है। प्लेटफॉर्म पर गेंद द्वारा आरोपित अभिलम्ब बल का मान (न्यूटन में) ज्ञात कीजिए। घर्षण अनुपस्थित है।

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**Ans. 5**

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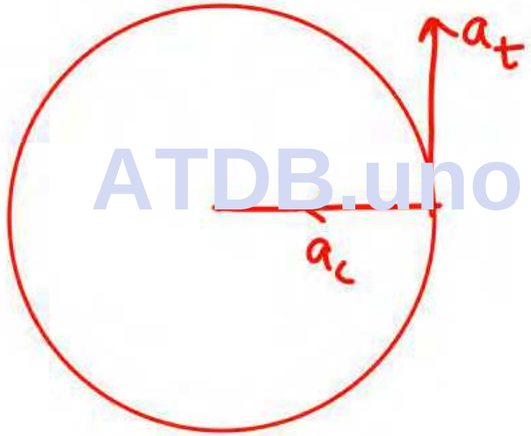
radial acceleration & tangential acceleration are equal. If at $t = 0$ velocity of particle is $V_0$. Find the speed of the particle after time $t = \frac{R}{2V_0}$

↳ $a_N$ , $a_c$

एक कण R त्रिज्या के वृत्ताकार पथ में इस प्रकार गति करता है कि प्रत्येक क्षण इसके त्रिज्यीय त्वरण तथा स्पर्शरेखीय त्वरण का परिमाण बराबर है। यदि $t = 0$ पर कण का वेग $V_0$ है तो समय $t = \frac{R}{2V_0}$ के पश्चात् कण की चाल ज्ञात कीजिए।

**Ans.** $2V_0$

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$a_c = a_t$

$\frac{v^2}{R} = \frac{dv}{dt}$

$\frac{dv}{v^2} = \frac{dt}{R}$

$\int_{V_0}^{V_f} \frac{dv}{v^2} = \int_0^{\frac{R}{2V_0}} \frac{dt}{R}$



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of length 0.3m are placed along a diameter of a turn table. The coefficient of friction between the table and $m_1$ is 0.5 while there is no friction between $m_2$ and the table. The table is rotating with an angular velocity of 10rad/sec about a vertical axis passing through its centre. The masses are placed along the diameter of the table on either side of the centre O such that $m_1$ is at a distance of 0.124 m from O. The masses are observed to be at rest with respect to an observer on the turn table.

(i) Calculate the frictional force on $m_1$

(ii) What should be the minimum angular speed of the turn table so that the masses will slip from this position.

$r_1 + r_2 = .3$

(iii) How should the masses be placed with the string remaining taut, so that there is no frictional force acting on the mass m.

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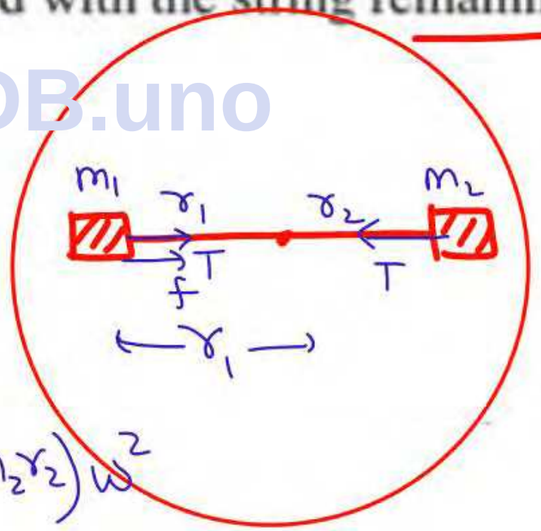


① $T + f = m_1 r_1 \omega^2$

$T = m_2 r_2 \omega^2$

② $f = \mu mg$ (put)

$f = \mu mg = (m_1 r_1 - m_2 r_2)\omega^2$

③ put $f = 0$ in eq ① $m_1 r_1 = m_2 r_2$

**Ans.** (i) 36N, (ii) 11.66rad/sec, (iii) 0.1m, 0.2m

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with angular velocity ω and angular acceleration α about its end. If μ is coefficient of friction. Mark the correct option. (Rod rotates in the plane of paper.)

(A*) If $\mu = \frac{\omega^2}{\alpha}$ friction on bead is static in nature

(B) If $\mu > \frac{\omega^2}{\alpha}$ friction on bead is kinetic in nature

(C) If $\mu < \frac{\omega^2}{\alpha}$ friction is static

(D) If bead does not slide relative to rod. Friction will not exist between bead and rod.

$H_2$ floor
mg → अंदर

$f_s = m a_c$

$\mu_s N \geq mR\omega^2$ = फिसलेगा नहीं जरूरत

एक कण (मोती) गुरूत्वविहीन क्षेत्र में स्थित छड़ पर ही चित्रानुसार गति कर सकता है। इस छड़ को इसके सिरे के परित: कोणीय वेग ω तथा कोणीय त्वरण α से घूर्णन कराया जाता है। यदि घर्षण गुणांक μ हो तो सही कथन चुनिये। (छड़ कागज के तल में घूर्णन करती है)

(A) यदि $\mu = \frac{\omega^2}{\alpha}$ हो तो कण पर कार्यरत् घर्षण स्थैतिक प्रकृति का है।

(B) यदि $\mu > \frac{\omega^2}{\alpha}$ हो तो कण पर कार्यरत् घर्षण गतिक प्रकृति का है।

(C) यदि $\mu < \frac{\omega^2}{\alpha}$ हो तो घर्षण स्थैतिक है।

(D) यदि कण, छड़ के सापेक्ष गति नहीं करता है तो कण व छड़ के मध्य घर्षण विद्यमान नहीं होगा।

$\mu_s m a_t \geq mR\omega^2$

$\mu_s mR\alpha \geq mR\omega^2$

$\mu_s \alpha \geq \omega^2$ = नहीं फिसलेगा
f → static

$\mu \geq \frac{\omega^2}{\alpha}$

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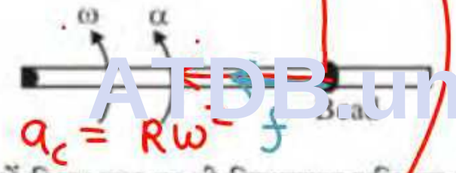
with angular velocity ω and angular acceleration α about its end. If μ is coefficient of friction. Mark the correct option. (Rod rotates in the plane of paper.)

(A*) If $\mu = \frac{\omega^2}{\alpha}$ friction on bead is static in nature

(B) If $\mu > \frac{\omega^2}{\alpha}$ friction on bead is kinetic in nature

(C) If $\mu < \frac{\omega^2}{\alpha}$ friction is static

(D) If bead does not slide relative to rod. Friction will not exist between bead and rod.




एक कण (मोती) गुरूत्वविहीन क्षेत्र में स्थित छड़ पर ही चित्रानुसार गति कर सकता है। इस छड़ को इसके सिरे के परितः कोणीय वेग ω तथा कोणीय त्वरण α से घूर्णन कराया जाता है। यदि घर्षण गुणांक μ हो तो सही कथन चुनिये।
(छड़ कागज के तल में घूर्णन करती है)

(A) यदि $\mu = \frac{\omega^2}{\alpha}$ हो तो कण पर कार्यरत् घर्षण स्थैतिक प्रकृति का है।

(B) यदि $\mu > \frac{\omega^2}{\alpha}$ हो तो कण पर कार्यरत् घर्षण गतिक प्रकृति का है।

(C) यदि $\mu < \frac{\omega^2}{\alpha}$ हो तो घर्षण स्थैतिक है।

(D) यदि कण, छड़ के सापेक्ष गति नहीं करता है तो कण व छड़ के मध्य घर्षण विद्यमान नहीं होगा।

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**4.** On a circular turn table rotating about its center horizontally with uniform angular velocity ω rad/s placed two blocks of mass 1 kg and 2 kg, on a diameter symmetrically about center. Their separation is 1m and friction is sufficient to avoid slipping. The spring between them as shown is stretched and applied force of 5N. If $f_1$ and $f_2$ are values of friction on 1 kg & 2kg block respectively:-

$r_1 = r_2 = R$

(A) For $\omega = 2$ rad/s, $f_1 = 3N$ & $f_2 = 1N$

(B) For $\omega = 3$ rad/s, $f_1 = 0.5$ N & $f_2 = 4N$

(C) For $\omega = \sqrt{10}$ rad/s, $f_1 = 0$ & $f_2 = 5N$

(D) For $\omega = \sqrt{10}$ rad/s, $f_1 = 0$ & $f_2 = 0N$

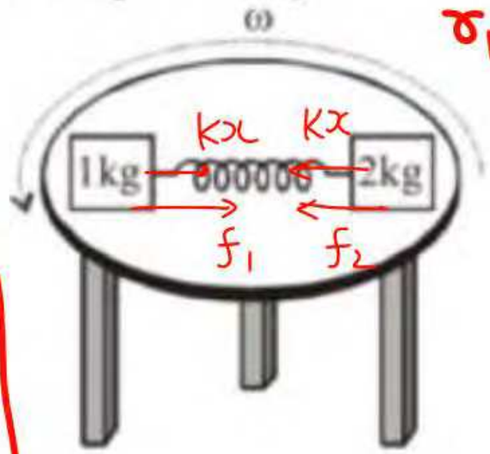
$Kx + f_1 = m_1 R\omega^2$

$Kx + f_2 = m_2 R\omega^2$

or

$5 - f_1 = 1 \times \frac{1}{2} \times \omega^2$

$5 + f_2 = 2 \times \frac{1}{2} \times \omega^2$




$r_1 = r_2 = R = \frac{1}{2}$

(A, B, C)

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H/W

tension in the ring is :

त्रिज्या r एवं प्रति एकांक लम्बाई द्रव्यमान m वाली एक वलय मुक्ताकाश में ω कोणीय वेग से घूर्णन कर रही है, वलय में तनाव होगा

(A) zero (B) $\frac{1}{2}m\omega^2r^2$ (C) $m\omega^2r^2$ (D) $mr\omega^2$

**Ans. (C)**

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