PRAYAS

JEE 2025

Lecture - 2

Physics

Circular Motion

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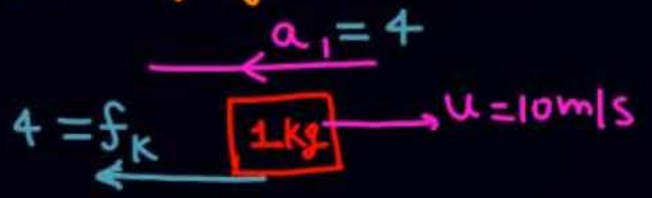
Topics *to be covered*

1. a_c, a_t Circular motion
2.
3.
4.

Q

① find time when relative motion stopped and velocity of block & platform at that time.

Sol^n



$f_k = \mu N$

$= .4 \times 10$

$\boxed{f_k = 4}$

$a_2 = \frac{f_k}{m_B} = \frac{4}{4} = 1$

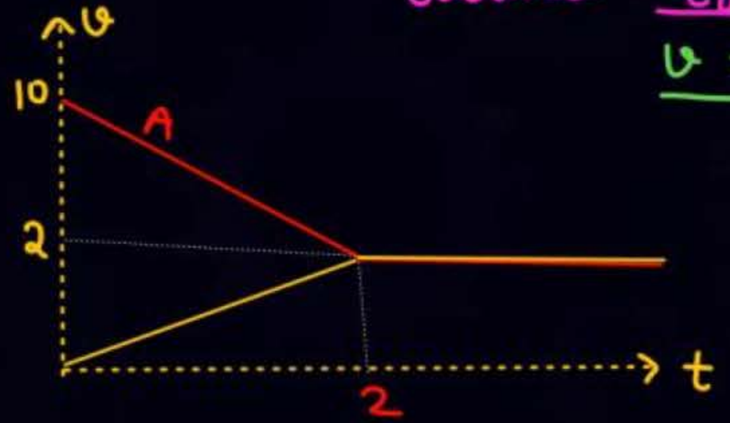
time = t_0

$v = u + at \Rightarrow v = 10 - 4t_0$ (A)

$v = 0 + 1t_0$ (B)

Substract $t_0 = 2\,sec$

$v = 2\,m/s$



$(F_{net})_{ext} = 0$,

$(K\cdot\varepsilon)_i = \frac{1}{2}\times 1\times 10^2 + 0 = 50$

$(K\varepsilon)_f = \frac{1}{2}\times 1\times 2^2 + \frac{1}{2}\times 4\times 2^2 = 10$

$\Delta K\cdot\varepsilon = 10-50 = -40$

$P_i = P_f$

$1\times 10 + 0 = 1\times v + 4v \Rightarrow \boxed{v = 2 m/s}$

$W_g + W_N + W_f = \Delta K\varepsilon$

$0 + 0 + W_f = -40$

$\boxed{(WD)_f = -40}$

(c) what should be min value of L so that block does not fall.

(wrt ground)

$(S_A)_{wrt\ ground} = 10\times 2 - \frac{1}{2}\times 4\times 2^2 = 12$

$(S_B)_{wrt\ ground} = 0 + \frac{1}{2}\times 1\times 2^2 = 2$

$S_{A/B} = 12-2 = 10$

Relative

$u_{A/B} = 10-0 = 10$

$a_{A/B} = -4-1 = -5$

$v_{A/B} = u_{A/B} + a_{A/B}t_0$

$0 = 10-5t_0$, $t_0 = 2$

$v^2 = u^2 + 2as$ (wrt B)

$0 = 100 - 2\times 5\times L$, $L = 10m$

→ Responsible to change the magnitude of velocity

tangential acc $= a\cos\theta$

= Component of acc along velocity

$$a_t = a\cos\theta = \frac{\vec{a}\cdot\vec{v}}{v} \text{ (magnitude)}$$

$$\vec{a}_t = \frac{\vec{a}\cdot\vec{v}}{v}\hat{v}$$

* a_t = Rate of change of speed

$$\frac{d(\text{speed})}{dt} = a_t$$

* $\vec{a}_t, \vec{v}$ parallel speed up

* $\vec{a}_t, \vec{v}$ antiparallel speed down.

→ Responsible to change dirⁿ of velocity.

* $a_N = a\sin\theta$

* $\vec{a}_N = \vec{a} - \vec{a}_t$

* $\vec{a} = \vec{a}_t + \vec{a}_N$

$$\sqrt{a_t^2 + a_N^2} = a$$

$$\frac{d\vec{v}}{dt} = \vec{a}_{net}$$

* $\frac{d(\text{speed})}{dt} = a_t$

If speed → const ⇒ $a_t = 0$,

dirⁿ → Const ⇒ $a_N = 0$

Style
रटना नहीं है

$$\begin{cases} \dfrac{d\vec{v}}{dt} = \vec{a} = \vec{a}_t + \vec{a}_N \\ \dfrac{d}{dt}|\vec{v}| = a_t \\ \left|\dfrac{d\vec{v}}{dt}\right| = |\vec{a}| = \text{mag. of acc} = \sqrt{a_t^2 + a_N^2} \end{cases}$$

$$a_t = a\cos\theta = \frac{\vec{a}\cdot\vec{v}}{v} = \frac{d|\vec{v}|}{dt}$$

$$\vec{a}\cdot\vec{v} = av\cos\theta$$

$$a\cos\theta = \frac{\vec{a}\cdot\vec{v}}{v}$$

Q $\vec{v} = 3\hat{i} + 4\hat{j}$

$\vec{a} = \hat{i} + \hat{j}$

① $a_t = a\cos\theta = \frac{\vec{a}\cdot\vec{v}}{v} = \frac{7}{5}$

② $\vec{a}_t = \frac{7}{5}\cdot\hat{v} = \frac{7}{5}\left(\frac{3\hat{i}+4\hat{j}}{5}\right) = \frac{21\hat{i}+28\hat{j}}{25}$

③ $\vec{a}_N = \vec{a} - \vec{a}_t = (\hat{i}+\hat{j}) - \left(\frac{21\hat{i}+28\hat{j}}{25}\right)$

$= \frac{4\hat{i}-3\hat{j}}{25}$

④ $\frac{d}{dt}\vec{v} = \hat{i}+\hat{j}$

⑤ $\left|\frac{d\vec{v}}{dt}\right| = \sqrt{2}$

⑥ $\frac{d|\vec{v}|}{dt} = a_t = \frac{7}{5}$

⑦ find rate of change of speed $= \frac{7}{5}$

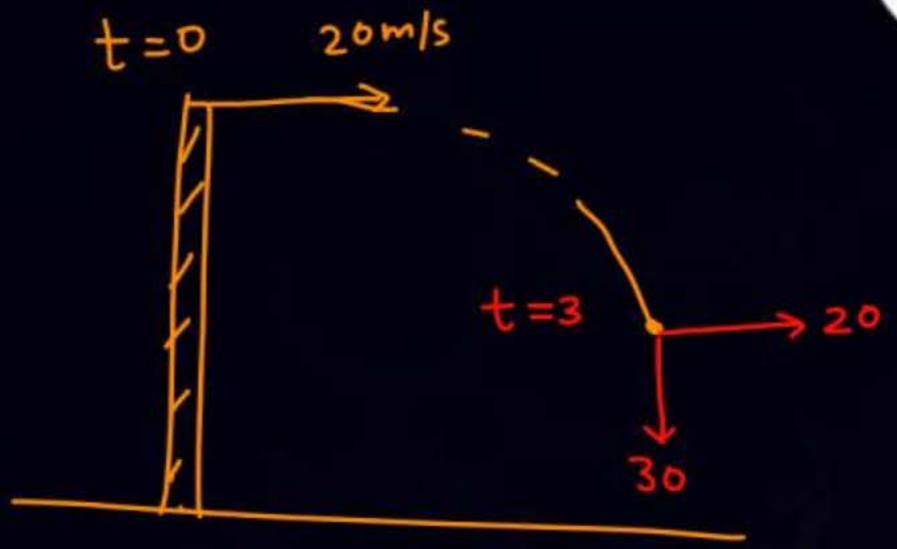
Q

$t=4$, $\vec{v} = 80\hat{i} + 20\hat{j}$

$\vec{a} = -10\hat{j}$

$\vec{a}_t = ?$ $\vec{a}_N = \surd$

Q



$t=3$ $\vec{v} = 20\hat{i} - 30\hat{j}$

$\vec{a} = -10\hat{j}$

तरीका

Q $\vec{v} = 3t\hat{i} + 4\hat{j}$

find $\vec{a}_t, \vec{a}_N$ at $t = 1$ sec

$\vec{a} = 3\hat{i}$

$t=1$ $\vec{v} = 3\hat{i} + 4\hat{j}$

$a_t = \checkmark$ $a_N = \checkmark$

Q $\vec{v} = 3t^2\hat{i} + 4t\hat{j}$

find $\vec{a}_N$ at $t = 1$ sec

Sol' $\vec{a} = 6t\hat{i} + 4\hat{j}$

$t = 1 \Rightarrow \vec{a} = 6\hat{i} + 4\hat{j}$

$\vec{v} = 3\hat{i} + 4\hat{j}$

$a_t = \checkmark$, $\vec{a}_N = \vec{a} - \vec{a}_t$

Q $\vec{r} = 3t^3\hat{i} + (4t^2 - 2)\hat{j} + 4t^2\hat{k}$

find $\vec{a}_N$ at $t = 1$ sec

Sol^n

$\vec{v} = 9t^2\hat{i} + 8t\hat{j} + 8t\hat{k}$

$\vec{a} = 18t\hat{i} + 8\hat{j} + 8\hat{k}$

$\vec{a}_t = \checkmark$

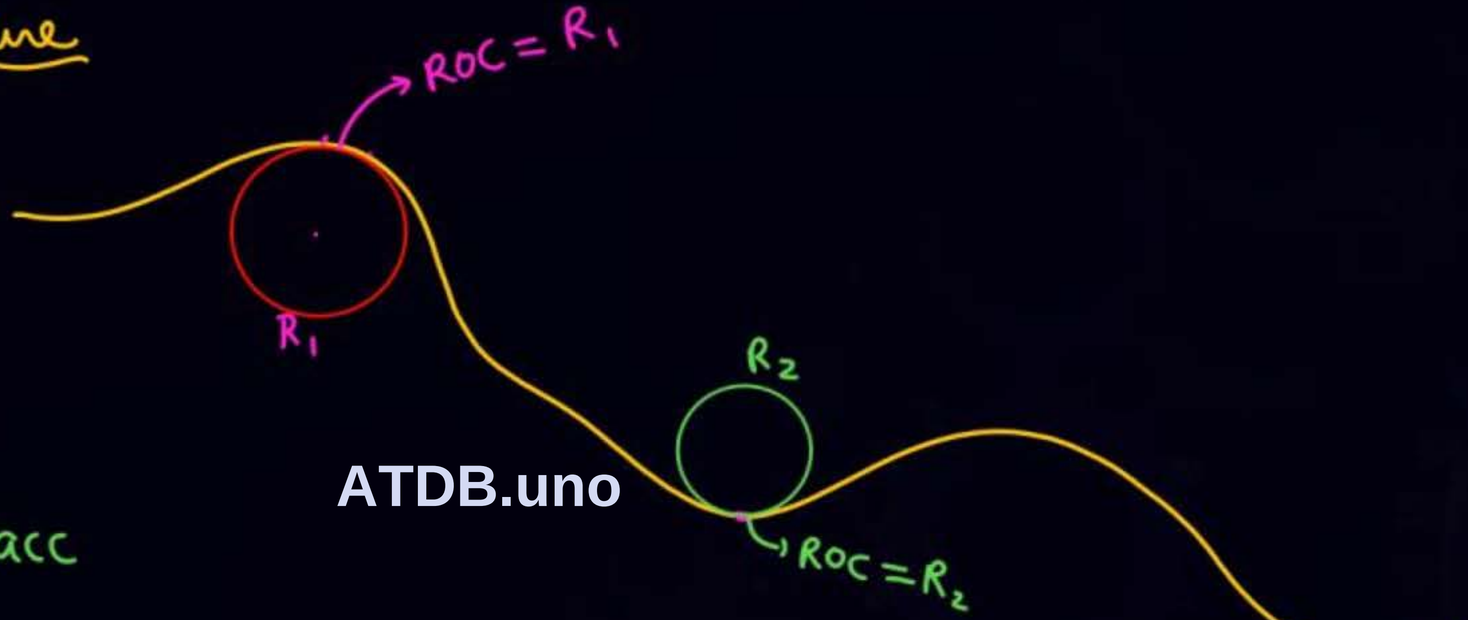
$\vec{a}_N = \checkmark$

Radius of Curvature

$$ROC = \frac{V^2}{a_N} \quad (?)$$

$V \longrightarrow$ speed

$a_N \longrightarrow$ normal acc



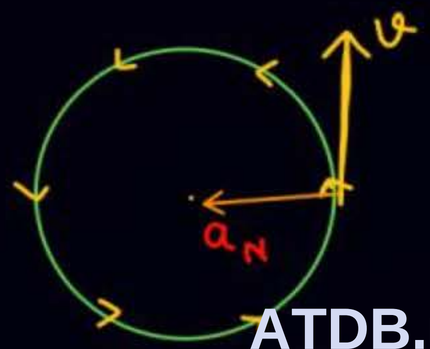
Circular motion

$$\vec{a} = \vec{a}_t + \vec{a}_N$$

① Uniform Circular motion

- Speed const
- $a_t = 0$
- $\hat{v} \longrightarrow$ change
- $\vec{a}_{net} = \vec{a}_N = \vec{a}_c$
- $\vec{a}_N = \vec{a}_c = \frac{v^2}{R}$ (Towards Center)

Centripital acc



$v \rightarrow$ Const

($v \longrightarrow$ speed)

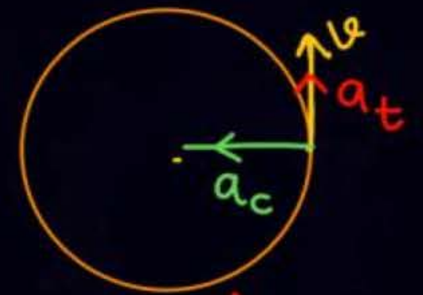
- $\frac{mv^2}{R} = F_{net}$ towards the center $\equiv$ Centripital force.

Non Uniform Circular motion

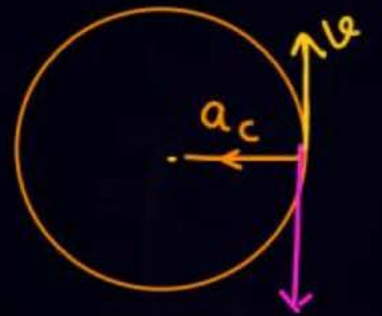
speed $\longrightarrow$ change

$a_t \neq 0$

$$a_{net} = \sqrt{a_t^2 + a_N^2} = \sqrt{a_t^2 + a_c^2}$$



Speed up



Speed down

angular displacement $= \theta$ rad/sec

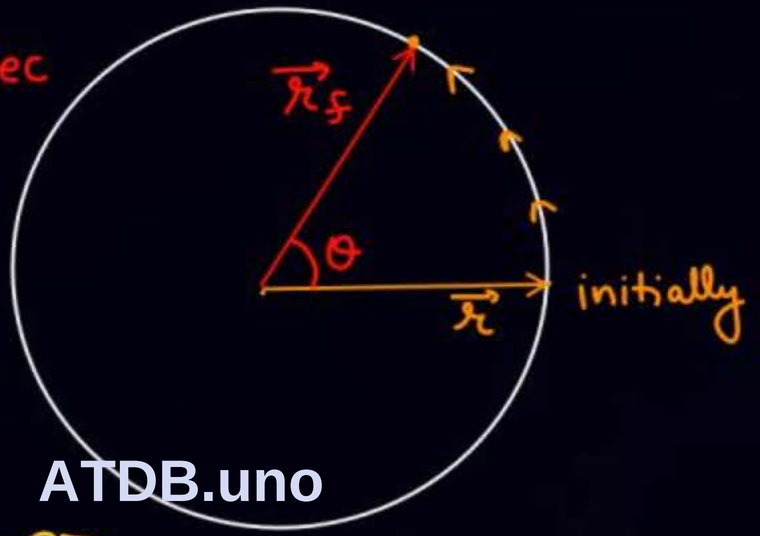
$\omega = \frac{d\theta}{dt}$ = Angular velocity

$\alpha = \frac{d\omega}{dt}$ = Angular acc

for one complete चक्कर

θ = angular Displacement $= 2\pi$

Displacement $= 0$



$x \longrightarrow \theta$

$v = \frac{dx}{dt} \longrightarrow \omega = \frac{d\theta}{dt}$

$v \longrightarrow \omega$

$a \longrightarrow \alpha$

$a = \frac{dv}{dt} \longrightarrow \alpha = \frac{d\omega}{dt}$

- $(x-t)$ slope $\Longrightarrow v$
- $(v-t)$ slope $\Longrightarrow a_{cc}$
- $(a-t)$ area $\Rightarrow \Delta\vec{v}$
- $(v-t)$ area $\Rightarrow$ Displacement

If $a_{cc} = \text{Const}$

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

$x \longrightarrow \theta$
$v \longrightarrow \omega$
$a \longrightarrow \alpha$
$F \longrightarrow \tau$
$P \longrightarrow L$
$J \longrightarrow H$

* $(\theta-t)$ slope $\Rightarrow \omega$ देगा
* $(\omega-t)$ slope $\Rightarrow \alpha$ देगा
* $(\alpha-t)$ area $\Rightarrow \Delta\omega$
* $(\omega-t)$ area $\Rightarrow$ angular displacement

If $\alpha \longrightarrow \text{Const}$

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

Q $x = 3t^3$

find v & a at $t = 2$ sec

$v = 9t^2$

$a = 18t$

Q Particle start rotating in a horizontal plane in a circular path of radius R.

St. $\theta = 3t^3$

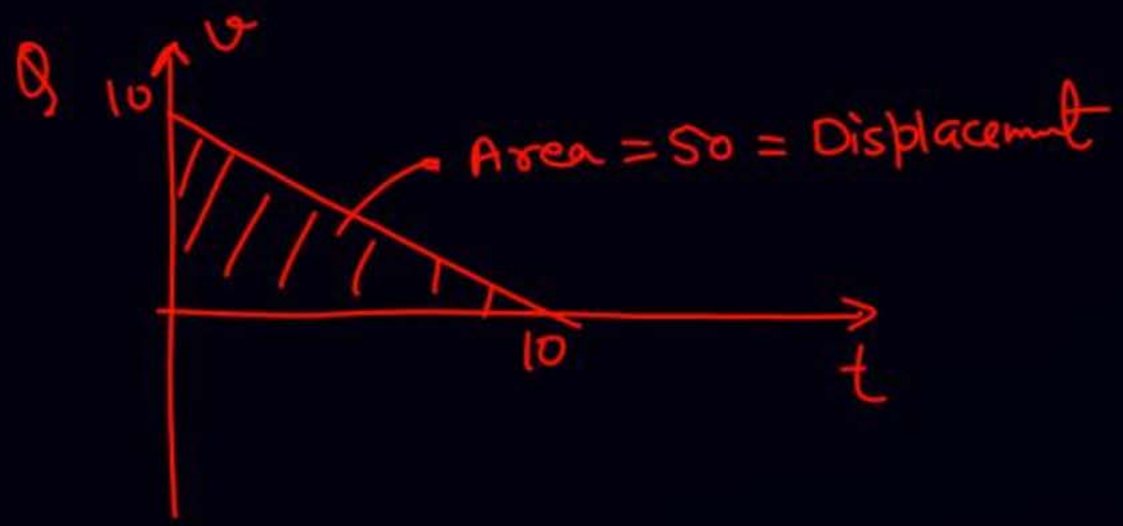
find ω, α at $t = 2$ sec

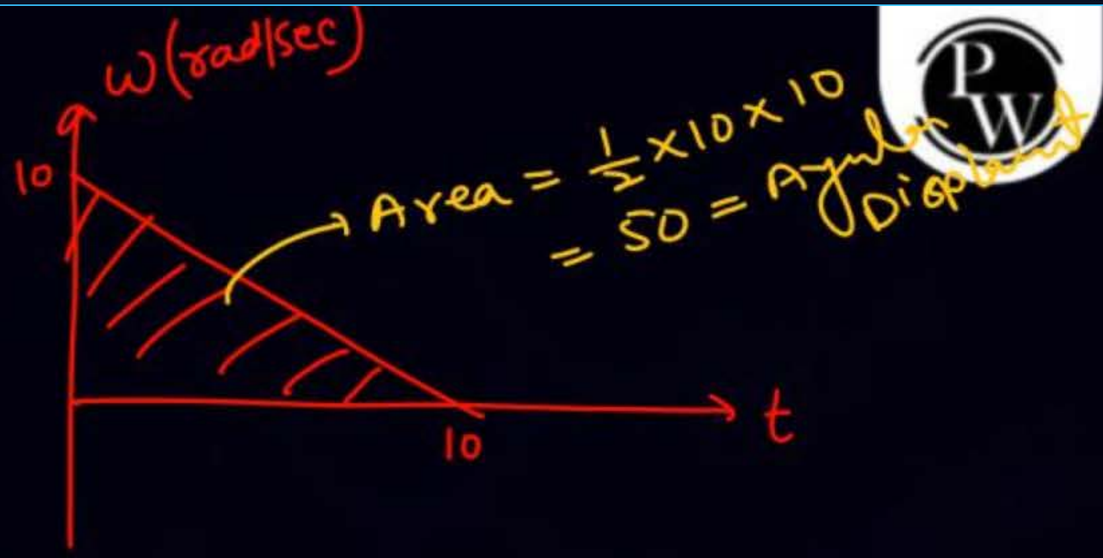
① $\omega = \frac{d\theta}{dt} = 9t^2$ $t = 2$, $\omega = 36 \frac{rad}{sec}$

② $\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt} = 18t$

$t = 2$

$\alpha = 36 \frac{rad}{sec^2}$





ATDB.uno

HomeWork

- module H.W.

motion In a plane ⇒ Prarambh ⇒ 77, 82, 88, 37, 48, 56, 64, 72,

Prabal ⇒ 9, 15, 21, 23, 18, 26, 48,

- JM PYQ attacheed ≡ Calculation ई ≡ practice them

⟶ (5-6) ques अटची ई I will Discuss them in next class

QUESTION

A block starts moving up an inclined plane of inclination 30° with an initial velocity of v_0. It comes back to its initial position with velocity $\frac{v_0}{2}$. The value of the coefficient of kinetic friction between the block and the inclined plane is close to $\frac{1}{1000}$. The nearest integer to I is _____.

[JEE Main – 2020]

Ans : (346)

QUESTION

The coefficient of static friction between a wooden block of mass 0.5 kg and a vertical rough wall is 0.2. The magnitude of horizontal force that should be applied on the block to keep it adhere to the wall will be _____N. [g = 10 ms^{-2}]. **[JEE Main – 2021]**

Ans : (25)

QUESTION

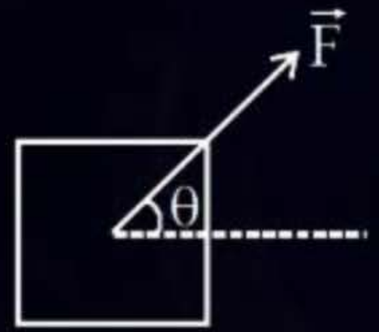
An inclined plane is bent in such a way that the vertical cross-section is given by $y = \frac{x^2}{4}$ where y is in vertical and x in horizontal direction. If the upper surface of this curved plane is rough with coefficient of friction $\mu = 0.5$, the maximum height in cm at which a stationary block will not slip downward is _____ cm. **[JEE Main – 2021]**

Ans : (25)

QUESTION

A block of mass m slides along a floor while a force of magnitude F is applied to it at angle θ as shown in figure. The coefficient of kinetic friction is μ_k. Then, the block's acceleration 'a' is given by: (g is acceleration due to gravity) **[JEE Main – 2021]**

1. $-\frac{F}{m}\cos\theta - \mu_k\left(g - \frac{F}{m}\sin\theta\right)$
2. $\frac{F}{m}\cos\theta - \mu_k\left(g - \frac{F}{m}\sin\theta\right)$
3. $\frac{F}{m}\cos\theta - \mu_k\left(g + \frac{F}{m}\sin\theta\right)$
4. $\frac{F}{m}\cos\theta + \mu_k\left(g - \frac{F}{m}\sin\theta\right)$



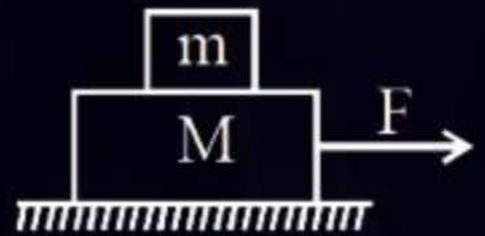
Ans : (2)

QUESTION

Two blocks (m = 0.5 kg and M = 4.5 kg) are arranged on a horizontal frictionless table as shown in figure. The coefficient of static friction between the two blocks is $\frac{3}{7}$. Then the maximum horizontal force that can be applied on the larger block so that the blocks move together is _____ N.

(Round off to the Nearest Integer) [Take g as 9.8 ms^{-2}].

[JEE Main – 2021]

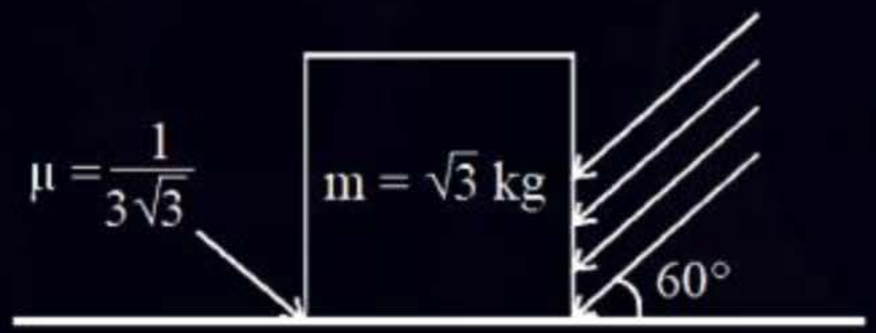


Ans : (21)

QUESTION

As shown in the figure, a block of mass $\sqrt{3}$ kg is kept on a horizontal rough surface of coefficient of friction $\frac{1}{\sqrt{x}}\left(\frac{\alpha^2-1}{\alpha^2}\right)$. The critical force to be applied on the vertical surface as shown at an angle 60° with horizontal such that it does not move, will be 3x. The value of x will be. [g = 10 m/s^2; $\sin 60° = \frac{\sqrt{3}}{2}$; $\cos 60° = \frac{1}{2}$].

[JEE Main – 2021]



Ans : (3)

QUESTION

A body of mass 1 kg rests on a horizontal floor with which it has a coefficient of static friction $\frac{1}{\sqrt{3}}$. It is desired to make the body move by applying the minimum possible force F N. The value of F will be _____.
(Round off to the Nearest Integer) [Take g = 10 ms^{-2}].

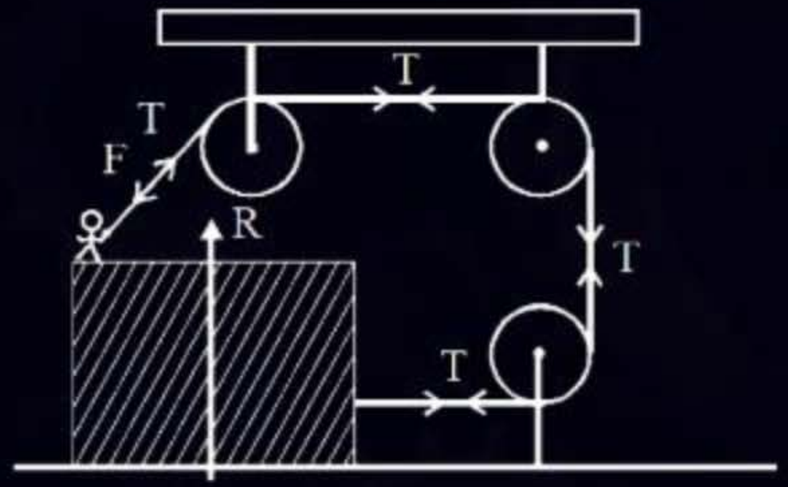
[JEE Main – 2021]

Ans : (5)

QUESTION

A boy of mass 4 kg is standing on a piece of wood having mass 5 kg. If the coefficient of friction between the wood and the floor is 0.5, the maximum force that the boy can exert on the rope so that the piece of wood does not move from its place is _____N. (Round off to the Nearest Integer) [Take g = 10 ms^{-2}].

[JEE Main – 2021]



Ans : (30)

QUESTION

A body of mass 'm' is launched up on a rough inclined plane making an angle of 30° with the horizontal. The coefficient of friction between the body and plane is $\frac{\sqrt{x}}{5}$ if the time of ascent is half of the time of descent. The value of x is _____. **[JEE Main – 2021]**

Ans : (3)

QUESTION

A particle of mass M originally at rest is subjected to a force whose direction is constant but magnitude varies with time according to the relation $F = F_0\left[1-\left(\frac{t-T}{T}\right)^2\right]$ Where F_0 and T are constants. The force acts only for the time interval 2T. The velocity v of the particle after time 2 T is:

[JEE Main – 2021]

1. $2F_0T/M$
2. $F_0\,T/2M$
3. $4F_0\,T/3M$
4. $F_0\,T/3M$

Ans : (3)

QUESTION

The coefficient of static friction between two blocks is 0.5 and the table is smooth. The maximum horizontal force that can be applied to move the blocks together is _____N. (Take: $g = 10\ ms^{-2}$)

[JEE Main – 2021]

Ans : (15)

QUESTION

A car is moving on a plane inclined at 30° to the horizontal with an acceleration of $10\ ms^{-2}$ parallel to the plane upward. A bob is suspended by a string from the roof of the car. The angle in degrees which the string makes with the vertical is _____.
(Take $g = 10\ ms^{-2}$)

[JEE Main – 2021]

Ans : (30)

QUESTION

A block of mass M slides down on a rough inclined plane with constant velocity. The angle made by the incline plane with horizontal is θ. The magnitude of the contact force will be:

[JEE Main – 2022]

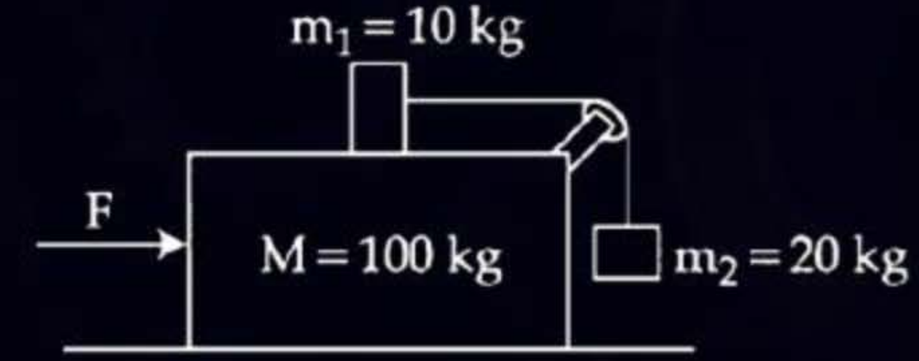
1. Mg
2. $Mg\cos\theta$
3. $\sqrt{Mg\sin\theta + Mg\cos\theta}$
4. $Mg\sin\theta\sqrt{1+\mu}$

Ans : (1)

QUESTION

Three masses M = 100 kg, m_1 = 10 kg and m_2 = 20 kg are arranged in a system as shown in figure. All the surface are frictionless and strings are inextensible and weightless. The pulleys are also weightless and frictionless. A force F is applied on the system so that the mass m_2 moves upward with an acceleration of 2 ms^{-2}. The value of F is: (Take g = 10 ms^{-2}).

[JEE Main – 2022]



1. 3360 N
2. 3380 N
3. 3120 N
4. 3240 N

Ans : (1)

QUESTION

In two different experiments, an object of mass 5 kg moving with a speed of 25^{-1} hits two different walls and comes to rest within (i) 3 second, (ii) 5 second, respectively.

[JEE Main – 2022]

1. Impulse and average force acting on the object will be same for both the cases.

2. Impulse will be same for both the cases but the average force will be different.

3. Average force will be same for both the cases but the impulse will be different.

4. Average force and impulse will be different for both the cases.

Ans : (2)

QUESTION

A uniform chain of 6 m length is placed on a table such that a part of its length is hanging over the edge of the table. The system is at rest. The co-efficient of static friction between the chain and the surface of the table is 0.5 , the maximum length of the chain hanging from the table is _____ m.

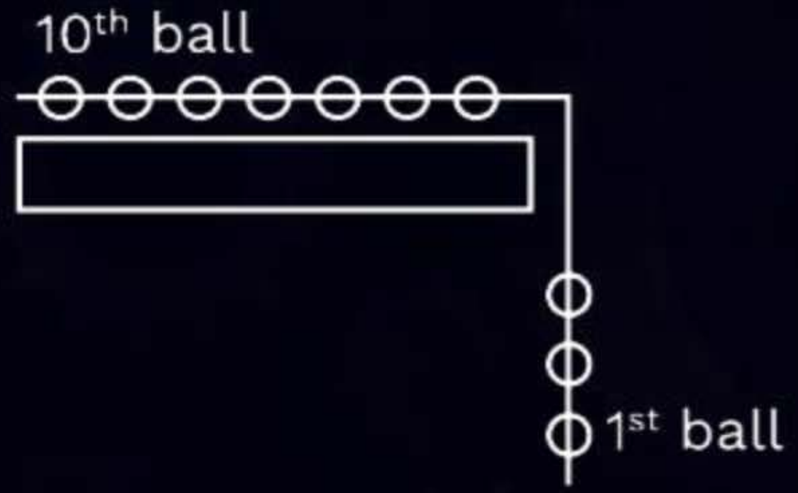
[JEE Main – 2022]

Ans : (2)

QUESTION

A system of 10 balls each of mass 2 kg are connected via massless and un-stretchable string. The system is allowed to slip over the edge of a smooth table as shown in figure. Tension on the string between the 7^{th} and 8^{th} ball is _____ N when 6^{th} ball just leaves the table.

[JEE Main – 2022]

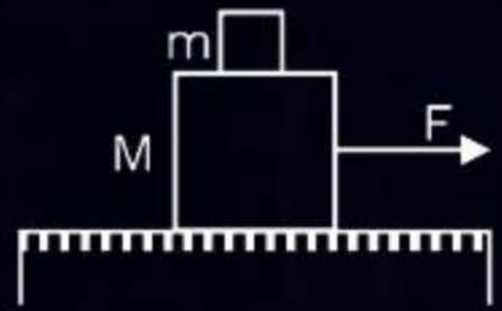


Ans : (36)

QUESTION

A system of two blocks of masses m = 2 kg and M = 8 kg is placed on a smooth table as shown in figure. The coefficient of static friction between two blocks is 0.5. The maximum horizontal force F that can be applied to the block of mass M so that the blocks move together will be:

[JEE Main – 2022]



1. 9.8 N
2. 39.2 N
3. 49 N
4. 78.4 N

Ans : (3)

QUESTION

A block of mass 2 kg moving on a horizontal surface with speed of 4 ms^{-1} enters a rough surface ranging from x = 0.5 m to x = 1.5 m. The retarding force in this range of rough surface is related to distance by F = –kx where k = 12 Nm^{-1}. The speed of the block as it just crosses the rough surface will be _____. **[JEE Main – 2022]**

1. Zero
2. 1.5 ms^{-1}
3. 2.0 ms^{-1}
4. 2.5 ms^{-1}

Ans : (3)

QUESTION

A block of mass 40 kg slides over a surface, when a mass of 4 kg is suspended through an inextensible massless string passing over frictionless pulley as shown below. The coefficient of kinetic friction between the surface and block is 0.02. The acceleration of block is _____. (Given g = 10 ms^{-2}).

[JEE Main – 2022]

1. $1\ ms^{-2}$
2. $1/5\ ms^{-2}$
3. $4/5\ ms^{-2}$
4. $8/11\ ms^{-2}$

Ans : (4)

QUESTION

Consider a block kept on an inclined plane (inclined at 45°) as shown in the figure. If the force required to just push it up the incline is 2 times the force required to just prevent it from sliding down, the coefficient of friction between the block and inclined plane (μ) is equal to:

[25 January 2023 - Shift 2]

1. 0.33
2. 0.60
3. 0.25
4. 0.50

Ans : (1)

QUESTION

A block of mass m slides down the plane inclined at angle 30° with an acceleration g/4. The value of coefficient of kinetic friction will be:

[29 January 2023 - Shift 1]

1. $\frac{2\sqrt{3}+1}{2}$
2. $\frac{1}{2\sqrt{3}}$
3. $\frac{\sqrt{3}}{2}$
4. $\frac{2\sqrt{3}-1}{2}$

Ans : (2)

QUESTION

Force acts for 20 s on a body of mass 20 kg, starting from rest, after which the force ceases and then body describes 50 m in the next 10 s. The value of force will be:

[29 January 2023 - Shift 2]

1. 40 N
2. 5 N
3. 20 N
4. 10 N

Ans : (2)

QUESTION

The time taken by an object to slide down 45° rough inclined plane is n times as it takes to slide down a perfectly smooth 45° incline plane. The coefficient of kinetic friction between the object and the incline plane is _____.

[29 January 2023 - Shift 2]

1. $\sqrt{\frac{1}{1-n^2}}$
2. $\sqrt{1-\frac{1}{n^2}}$
3. $1+\frac{1}{n^2}$
4. $1-\frac{1}{n^2}$

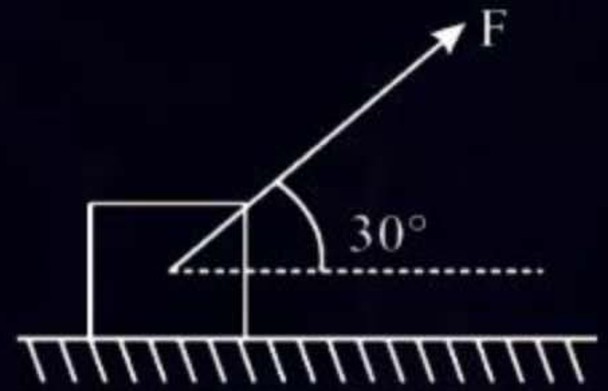
Ans : (4)

QUESTION

As shown in the figure a block of mass 10 kg lying on a horizontal surface is pulled by a force F acting at an angle 30°, with horizontal. For $\mu_s = 0.25$, the block will just start to move for the value of F: [Given $g = 10\ ms^{-2}$].

[01 February 2023 - Shift 2]

1. 33.3 N
2. 25.2 N
3. 20 N
4. 35.7 N



Ans : (2)

QUESTION

Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: An electric fan continues to rotate for some time after the current is switched off.

Reason R: Fan continues to rotate due to inertia of motion.

In the light of above statements, choose the most appropriate answer from the options given below.

[10 April 2023 - Shift 2]

1. A is correct but R is not correct
2. A is not correct but R is correct
3. Both A and R are correct and R is the correct explanation of A
4. Both A and R are correct but R is NOT the correct explanation of A

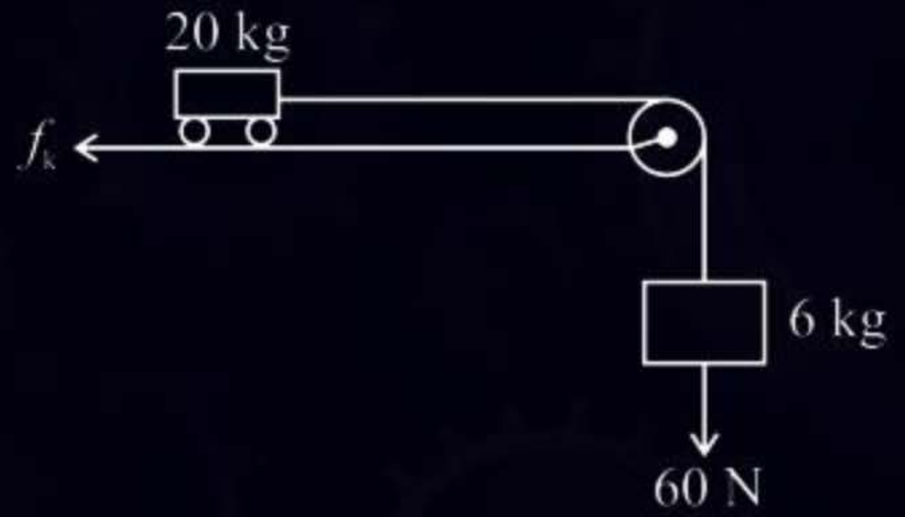
Ans : (3)

QUESTION

Consider a block and trolley system as shown in figure. If the coefficient of kinetic friction between the trolley and the surface is 0.04, the acceleration of the system in ms^{-2} is:

(Consider that the string is massless and unstretchable and the pulley is also massless and frictionless):

[01 Feb. 2024 - Shift 1]



1. 3
2. 4
3. 2
4. 1.2

Ans : (3)

QUESTION

A block of mass m is placed on a surface having vertical cross section given by $y = x^2/4$. If coefficient of friction is 0.5, the maximum height above the ground at which block can be placed without slipping is:

[30 Jan. 2024 - Shift 2]

1. 1/4 m
2. 1/2 m
3. 1/6 m
4. 1/3 m

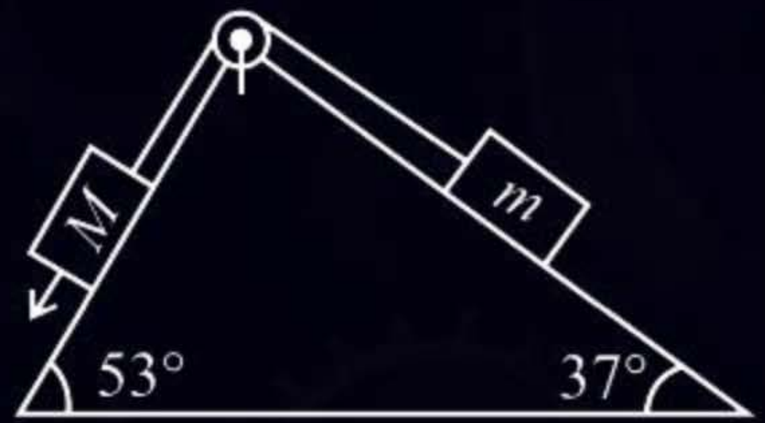
Ans : (1)

QUESTION

In the given arrangement of a doubly inclined plane two blocks of masses M and m are placed. The blocks are connected by a light string passing over an ideal pulley as shown. The coefficient of friction between the surface of the plane and the blocks is 0.25. The value of m, for which M = 10 kg will move down with an acceleration of 2 m/s^2, is:

(take g = 10 m/s^2 and tan37° = 3/4)

[31 Jan. 2024 - Shift 1]



1. 9 kg
2. 4.5 kg
3. 6.5 kg
4. 2.25 kg

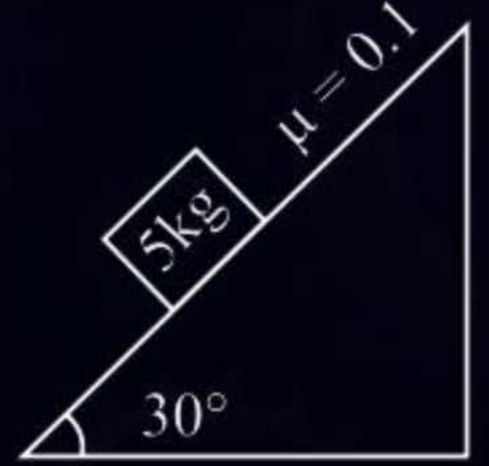
Ans : (2)

QUESTION

A block of mass 5 kg is placed on a rough inclined surface as shown in the figure. If $\vec{F}_1$ is the force required to just move the block up the inclined plane and $\vec{F}_2$ is the force required to just prevent the block from sliding down, then the value of $|\vec{F}_1| - |\vec{F}_2|$ is: [Use g = 10 m/s^2].

[We changed options. In official NTA paper no option was correct.] **[31 Jan. 2024 - Shift 2]**

1. $25\sqrt{3}$ N
2. $5\sqrt{3}$ N
3. $\frac{5\sqrt{3}}{2}$ N
4. 10 N



Ans : (2)