JEE and NEET CRASH COURSE

PHYSICS

50

$f = 49$

$f = 49$

$a = \frac{1}{10}$

$a = 0.1$

Problem Solving Class

(Law's of Motion & Friction)

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PQ4Q120

A lift is moving down with acceleration a. A man in the lift drops a ball inside the lift. The acceleration of the ball as observed by the man in the lift and a man standing stationary on the ground are respectively **AIEEE - 2002**

(A) g, g (B) g – a, g – a

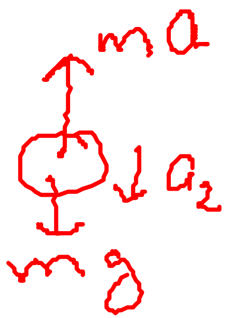
(C) g – a, g (D) a, g

w.r.t. ground

$$a_1 = \frac{mg}{m} = g \downarrow$$

w.r.t. lift

$$a_2 = \frac{\cancel{m}g - \cancel{m}a}{\cancel{m}}$$



PQ4S120

Ans [C]

For observer in the lift, acceleration = (g – a) For observer standing outside, acceleration = g.

- As acceleration is a vector quantity so the relative acceleration is $a_{xy} = a_x - a_y$. Taking downward acceleration as positive.
- As the ball is freefall so it will have g as acceleration wrt ground and the man inside lift will have the same acceleration as that of lift.

PQ4Q121

When forces F_1, F_2, F_3 are acting on a particle of mass m such that F_2 and F_3 are mutually perpendicular, then the particle remains stationary. If the force F_1 is now removed then the acceleration of the particle is

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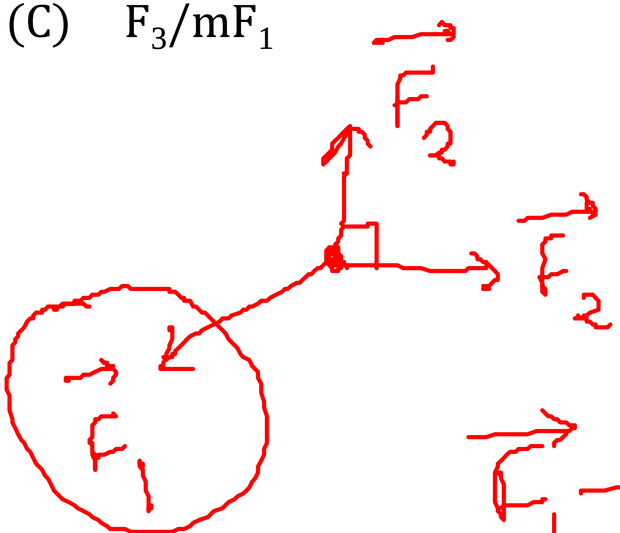
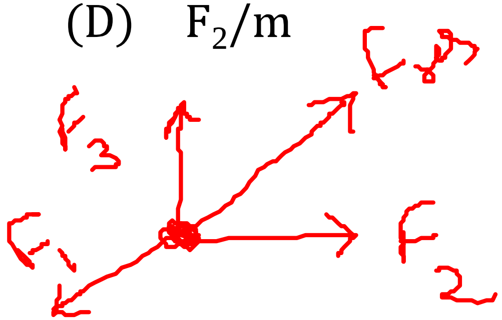
(A) F_1/m (B) F_2F_3/mF_1

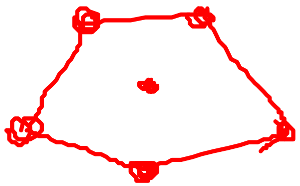
(C) F_3/mF_1 (D) F_2/m





$$\frac{\sqrt{F_2^2+F_3^2}}{m}$$ $= F_{res}$

$$\vec{F_1}+\vec{F_2}+\vec{F_3}=0$$



$$\boxed{a = \frac{F_1}{m}}$$

PQ4S121

Ans [A]

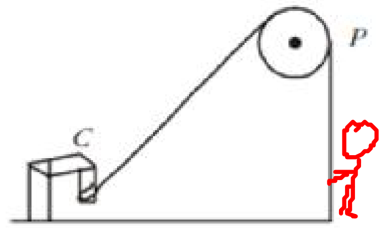
F_2 and F_3 have a resultant equivalent to F_1

$$\therefore \text{ Acceleration} = \frac{F_1}{m}.$$

- When forces F1, F2 and F3 are acting on the particle, it remains in equilibrium. Now, it is given that F2 and F3 are perpendicular to each other.
- So, we can infer that force F1 has to balance the resultant of the other two forces. $F_1 = \left(\sqrt{F_2^2} + F_3^2\right)$

PQ4Q122

One end of a massless rope, which passes over a massless and frictionless pulley P is tied to a hook C while the other end is free Maximum tension that the rope can bear is 960 N. With what value of maximum safe acceleration (in ms^{-2}) can a man of 60 kg climb on the rope?



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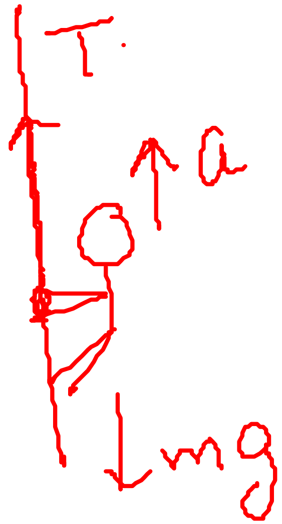
(A) 16 (B) 6

(C) 4 (D) 8



$T - mg = ma$

$a = \frac{T - mg}{m}$

$a_{max} = \frac{T_{max} - mg}{m} = \frac{960 - 600}{60}$

$a_{max} = \frac{360}{60} = 6 \, m/s^2$

PQ4S122

Ans [B]

$T - 60g = 60a$

or $960 - (60 \times 10) = 60a$

or $60a = 360$

or $a = 6\ ms^{-2}$

- If a man moves downward with acceleration a then its apparent weight deceases.
  Here m is the mass of the man and g is acceleration due to gravity
- In that condition tension in string m(g+a) this should not be exceed over breaking strength of the rope i.e.

PQ4Q123

A light string passing over a smooth light pulley connects two blocks of masses m_1 and m_2 (vertically). If the acceleration of the system is $g/8$, then the ratio of the masses is

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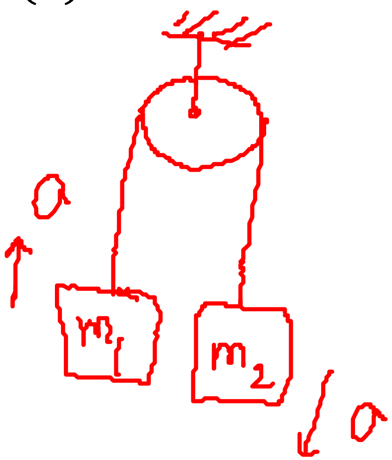
(A) 8 : 1 (B) 9 : 7

(C) 4 : 3 (D) 5 : 3



$$a = \left(\frac{m_2 - m_1}{m_2 + m_1}\right) g \Rightarrow \frac{1}{8} = \frac{m_2 - m_1}{m_2 + m_1}$$

$$m_2 + m_1 = 8m_2 - 8m_1$$

$$9m_1 = 7m_2$$

$$\frac{m_2}{m_1} = \frac{9}{7}$$

PQ4S123

Ans [B]

$$\frac{a}{g} = \frac{(m_1 - m_2)}{(m_1 + m_2)}$$

$$\therefore \ \frac{1}{8} = \frac{(m_1 - m_2)}{(m_1 + m_2)}$$

$$\text{or} \quad \frac{m_1}{m_2} = \frac{9}{7} \ .$$

Let mass of two blocks be m_1 and m_2 respectively and their common acceleration be a.

Applying equation of motion, assuming $m_2 > m_1$

Here T is the tension in the string.

$m_2g - T = m_2 \times a$

$T - m_1g = m_1 \times a$

Now substituting value of a as g/8 and eliminating T,

PQ4Q124

Three identical blocks of masses m = 2 kg are drawn by a force F = 10.2N with an acceleration of 0.6 ms^{-2} on a frictionless surface, then what is the tension (in N) in the string between the blocks B and C?

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(A) 9.2

(B) 7.8

(C) 4

(D) 9.8

$a = \frac{10.2}{6} = 1.7$

$T = 2 \times 1.7$

$= 3.4$ N

$T = ma$

$= 1.2$ N

$10.2 - T_{BC} = 4 \times 0.6$

$T_{BC} = 10.2 - 2.4$

PQ4S124

Ans [B]

Force = mass $\times$ acceleration

$\therefore F - T_{AB} = ma$

and $T_{AB} - T_{BC} = ma$

$\therefore T_{BC} = F - 2\,ma$

or $T_{BC} = 10.2 - (2 \times 2 \times 0.6)$

or $T_{BC} = 7.8$ N.

- The acceleration a due to the force F will be common to all the boxes.

  but the tension between the boxes will be different.
- So we will use F-T=ma (Remember tension btw different boxes is different)

Three forces start acting simultaneously on a particle moving with velocity $\vec{v}$. These forces are represented in magnitude and direction by the three sides of a triangle ABC (as shown). The particle will now move with velocity.

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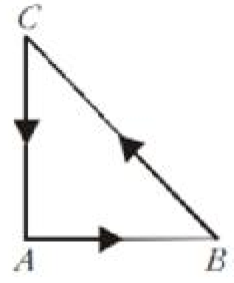

(A) 0

(B) 3v

(C) v/3

(D) v

$\vec{v}$

$\vec{F}_{res} = 0$

$\vec{a} = 0$

$\vec{v} = \text{const}$

PQ4S125

Ans [D]

By triangle of forces, the particle will be in equilibrium under the three forces. Obviously the resultant force on the particle will be zero. Consequently the acceleration will be zero. Hence the particle velocity remains unchanged at $\vec{v}$.

As the resultant force on particle is 0 , the velocity will be unchanged.

PQ4Q126

A spring balance is attached to the ceiling of a lift. A man hangs his bag on the spring and the spring reads 49 N, when the lift is stationary. If the lift moves downward with an acceleration of 5 m/s^2, the reading of the spring balance will be

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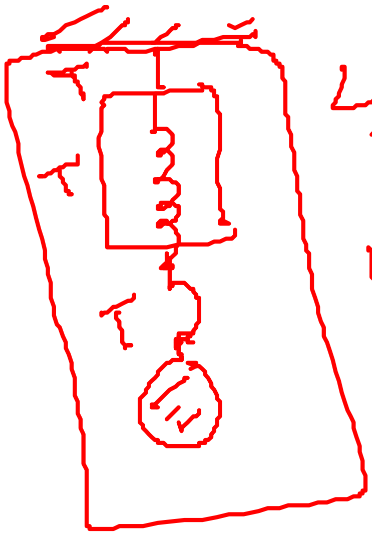
(A) 24 N (B) 74 N

(C) 15 N (D) 49 N



$49 = mg$

$49 = m \times 9.8$

$m = \frac{490}{98}$

$= 5$

$g_{eff} = g - a$

$\text{Reading} = m g_{eff}$

$= m(g - a)$

$= 49 - 25$

$= 24 \text{ N}$

PQ4S126

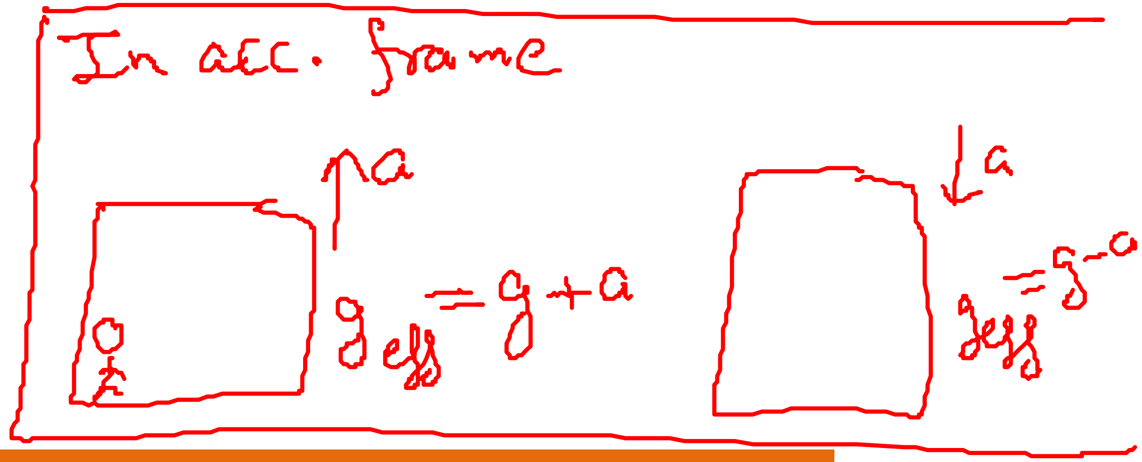
Ans [A]

When lift is standing, $W_1 = mg$ When the lift descends with acceleration a,

$W_2 = m(g - a)$

$$\therefore \frac{W_2}{W_1} = \frac{m(g-a)}{mg} = \frac{9.8-5}{9.8} = \frac{4.8}{9.8}$$

$$\text{or } W_2 = W_1 \times \frac{4.8}{9.8} = \frac{4.8 \times 4.8}{9.8} = 24 \text{ N}$$



- When the lift is stationary the spring force balances weight:
- kx is also the reading of spring balance so kx = mg = 49N

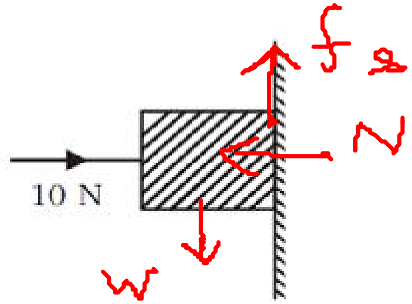
  (k = force constant of spring, x = elongation, True weight = 49N)

when lift moves with acceleration a downward we have:

$kx_2 = mg - a \times m$ (Pseudo force in lift frame upward, x_2=new elongation)

PQ4Q127

A horizontal force of 10 N is necessary to just hold a block stationary against a wall. The coefficient of friction between the block and the wall is 0.2. The weight of the block is



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(A) 20 N (B) 50 N

(C) 100 N (D) 2 N

$N = 10$

$f_s = W$

$f_s = \mu N$

$\mu N = W$

$W = 0.2 \times 10$

$= 2N$

PQ4S127

Ans [D]

Weight of the block is balanced by force of friction

$\therefore$ Weight of the block $= \mu R = 0.2 \times 10 = 2$ N.

Friction force balance the wight of the block friction force $f = \mu N$ where N is the normal reaction due to wall and μ is the coefficient of friction.

A marble block of mass 2 kg lying on ice when given a velocity of 6 m/s is stopped by friction in 10 s. Then the coefficient of friction is

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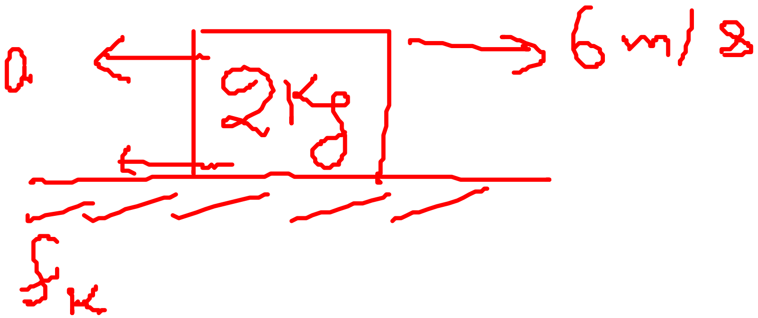
(A) 0.02 (B) 0.03

(C) 0.06 (D) 0.01



$$v = u + at$$

$$0 = 6 - a \times 10$$

$$a = 0.6$$

$$f_K = ma \Rightarrow \mu N = ma \Rightarrow \mu \cancel{m} g = \cancel{m} a$$

$$\mu g = 0.6 \Rightarrow \mu = \frac{0.6}{10} = 0.06$$

PQ4S128

Ans [C]

Frictional force provides the retarding force

$\therefore \mu mg = ma$

$$\text{or } \mu = \frac{a}{g} = \frac{u/t}{g} = \frac{6/10}{10} = 0.06.$$

Through the help of equation of motion we can calculate v = u + at. where a is the acceleration, t is the time and v is the velocity.

And ma=μmg where μ is the coefficient of friction.

A block of mass M is pulled along a horizontal frictionless surface by a rope of mass m. If a force P is applied at the free end of the rope, the force exerted by the rope on the block is

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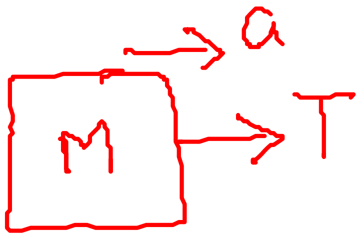
~~(A) P/m~~ (B) P/M

~~(C) P~~ (D) P/M+m

$$a = \frac{P}{M+m}$$



$$T = Ma = \frac{MP}{M+m}$$

PQ4S129

Ans [D]

$$\text{Acceleration of block (a)} = \frac{\text{Force applied}}{\text{Total mass}}$$

$$\text{or} \quad a = \frac{P}{M + m}$$

$$\therefore \quad \text{Force on block} = \text{Mass of block} \times a = \frac{PM}{M + m}$$

The system will accelerate due to the action of the force , all accelerating with same acceleration

Acceleration of the system = Total external force/Total mass

PQ4Q130

A light spring balance hangs from the hook of the other light spring balance and a block of mass M kg hangs from the former one. Then the true statement about the scale reading is

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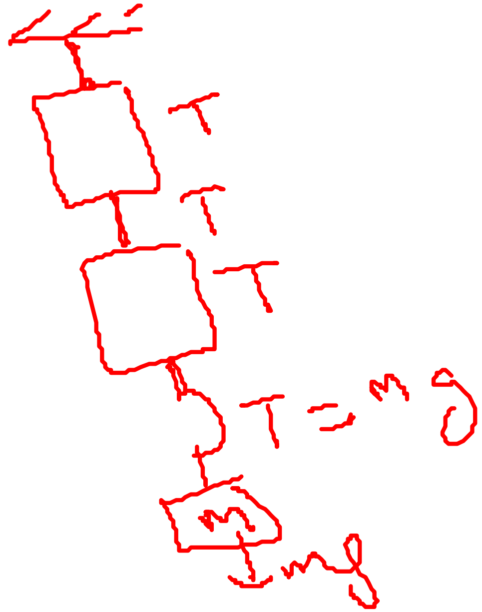
(A) Both the scales read M kg each

(B) The scale of the lower one reads M kg and of the upper one zero

(C) The reading of the two scales can be anything but the sum of the reading will be M kg

(D) Both the scales read M/2 kg

$T = mg$



PQ4S130

Ans [A]

Both the scales read M kg each.

Reading of spring balance = kx, x = change in length of spring from its natural length

PQ4Q131

A rocket with a liftoff mass 3.5×10^4 kg is blasted upwards with an initial acceleration of 10 m/s^2. Then the initial thrust of the blast is

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(A) 3.5×10^5 N (B) 3.5×10^4 N

(C) 3.65×10^4 N (D) 4.38×10^5 N

$F = ma$

$= 3.5\times10^4 \times 10$

$= 3.5\times10^5$ N

PQ4S131

Ans [A]

Initial thrust = (Lift off mass) × acceleration = $(3.5 \times 10^4) \times (10) = 3.5 \times 10^5$ N.

Thrust is nothing but Force so

Thrust = mass or lift off mass × acceleration

PQ4Q132

A machine gun fires a bullet of mass 40 g with a velocity 1200 ms^{-1}. The man holding it can exert a maximum force of 144 N on the gun. How many bullets can he fire per second at the most?

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(A) One

(B) Four

(C) Two

(D) Three

$$F = \frac{\Delta p}{\Delta t} \Rightarrow \overset{12}{\cancel{144}} = \frac{N\left(\frac{4\cancel{0}}{1\cancel{0}\cancel{0}\cancel{0}} \times \cancel{1200}\right)}{1\,s}$$

$$N = \frac{12}{4} = 3$$

PQ4S132

Ans [D]

Suppose he can fire n bullets per second

$\therefore$ Force = Change in momentum per second

$$144 = n \times \left(\frac{40}{1000}\right) \times (1200)$$

$$\text{or } n = \frac{144 \times 1000}{40 \times 1200}$$

Or n = 3.

Let n be the number of bullets that can be fired per second.

The force exerted F by man must balance the change in momentum (mv) of the bullets per second.

$F = mnv$

PQ4Q133

Two masses $m_1 = 5$ kg and $m_2 = 4.8$ kg tied to a string are hanging over a light frictionless pulley. What is the acceleration of the masses when lift free to move? ($g = 9.8\ m/s^2$)

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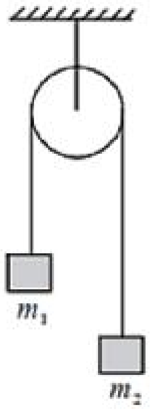

(A) $0.2\ m/s^2$ (B) $9.8\ m/s^2$

(C) $5\ m/s^2$ (D) $4.8\ m/s^2$

$$a = \frac{(m_1 - m_2)g}{m_1 + m_2} = \frac{5 - 4.8}{\cancel{(5+4.8)}} \times \cancel{9.8}$$

$$= 0.2\ m/s^2$$

PQ4S133

Ans [A]

$$\frac{a}{g} = \frac{(m_1 - m_2)}{(m_1 + m_2)} = \frac{(5 - 4.8)}{(5 + 4.8)} = \frac{0.2}{9.8}$$

$$\text{or } a = g \times \frac{0.2}{9.8} = \frac{9.8 \times 0.2}{9.8} = 0.2 \text{ ms}^{-2}$$

Acceleration of system = Fnet / Total mass

PQ4Q134

A block rests on a rough inclined plane making an angle of 30° with the horizontal. The coefficient of static friction between the block and the plane is 0.8. If the frictional force on the block is 10 N, the mass of the block (in kg) is (Take g = 9.8 m/s²)

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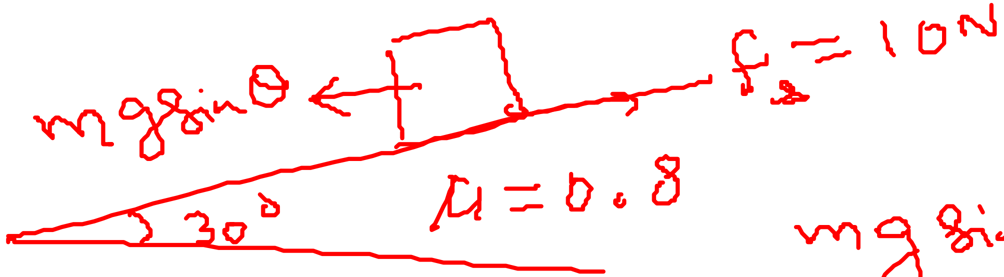
(A) 2.0 (B) 4.0

(C) 1.6 (D) 2.5

Sol



$$mg\sin\theta = f_s$$

$$m \times 9.8 \times \frac{1}{2} = 10$$

$$m = \frac{10}{4.9}$$

PQ4S134

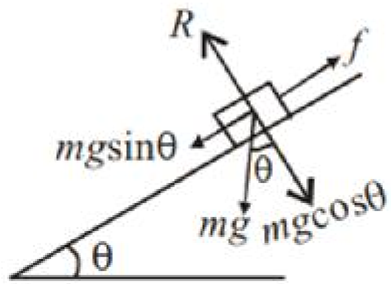
Ans [A]

For equilibrium of block,

$f = mg \sin\theta$

$\therefore 10 = m \times 10 \times \sin 30°$

or $m = 2$ kg.



As shown in the figure the component of gravity along the incline is down the incline which is mgsinθ ,now to stop the block from sliding friction should be up the incline and also equal to mgsin 30 i.e., friction= mgsinθ

PQ4Q136

A smooth block is released at rest on a 45° incline and then slides a distance d. The time taken to slide is n times as much to slide on rough incline than on a smooth incline. The coefficient of friction is

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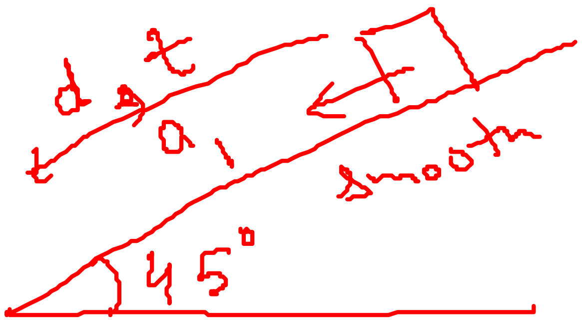
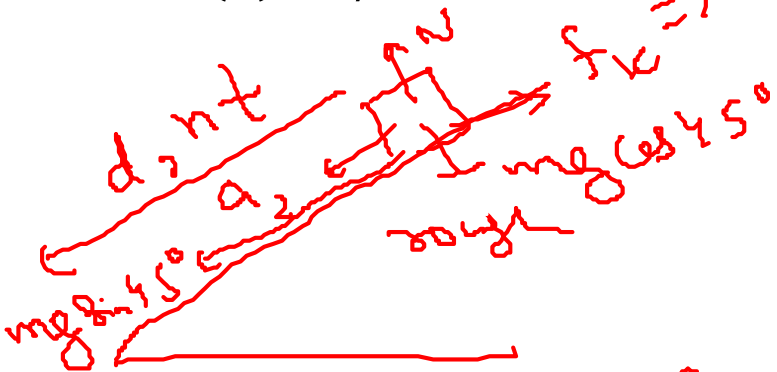
(A) $1/n^2$ (B) $1+1/(n^2)$

(C) $1-1/(n^2)$ ✓ (D) $2/n^2$



$f_k = \mu mg\cos 45^\circ$



$a_1 = g\sin 45^\circ = g/\sqrt{2}$

$d = \frac{1}{2}\cdot\frac{g}{\sqrt{2}}(t)^2$

$a_2 = g/\sqrt{2} - \mu\, g/\sqrt{2} = \frac{g}{\sqrt{2}}(1-\mu)$

$d = \frac{1}{2}\frac{g}{\sqrt{2}}(1-\mu)(nt)^2$

$\cancel{t^2} = (1-\mu)\cancel{t^2}n^2 \Rightarrow \frac{1}{n^2} = 1-\mu \Rightarrow \boxed{\mu = 1-\frac{1}{n^2}}$

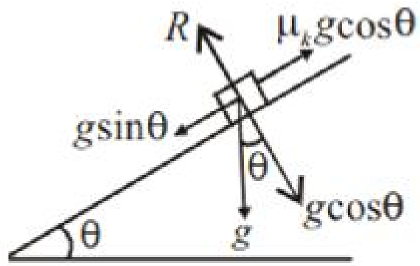
PQ4S136

Ans [C]

Component of g down the plane = g $\sin\theta$

$\therefore$ For smooth plane,

$$d = \frac{1}{2}(g\sin\theta)t^2 \qquad \ldots\ldots..(i)$$



For rough plane,

Frictional retardation up the plane = $\mu_k(g\cos\theta)$

$$\therefore d = \frac{1}{2}(g\sin\theta - \mu_k g\cos\theta)(nt)^2$$

$$\therefore \frac{1}{2}(g\sin\theta)t^2 = \frac{1}{2}(g\sin\theta - \mu_k g\cos\theta)\, n^2t^2$$

or $\sin\theta = n^2(\sin\theta - \mu_k g\cos\theta)$

or $\sin 45° = n^2(\sin 45° - \mu_k \cos 45°)$

or $\frac{1}{\sqrt{2}} = \frac{n^2}{\sqrt{2}}(1 - \mu_k)$ or $\mu_k = 1 - \frac{1}{n^2}$

$S = ut + \frac{1}{2}at^2$ along incline plane

For frictional surface:

$a = (g\sin\theta - \mu g\cos\theta)$

For smooth surface:

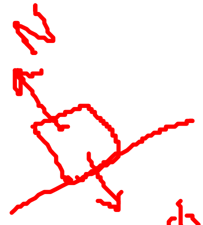
$a = g\sin\theta$

PQ4Q137

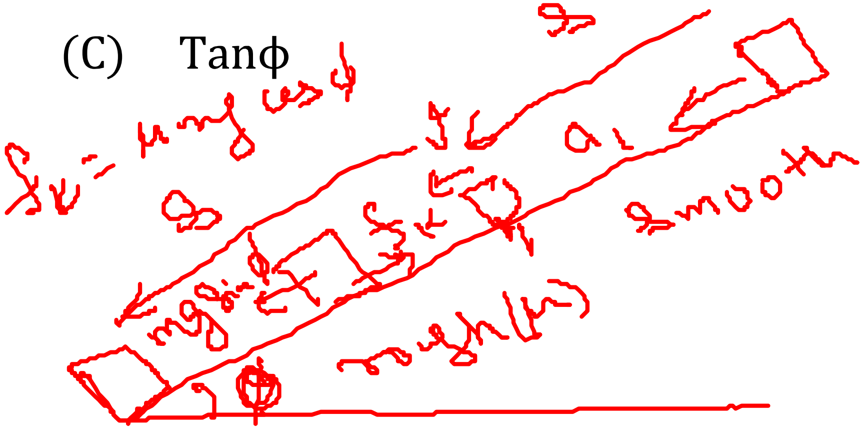
The upper half of an inclined plane with inclination ϕ is perfectly smooth while the lower half is rough. A body starting from rest at the top will again come to rest at the bottom if the coefficient of friction for the lower half is given by **AIEEE - 2005**

(A) $2\tan\phi$ (B) $\cos\phi$

(C) $\text{Tan}\phi$ (D) $\text{Sin}2\phi$



$f = \mu N$



$a_1 = g\sin\phi$

$a_2 = g\sin\phi - \mu g\cos\phi$

$v^2 = 0 + 2g\sin\phi \cdot s$ — ①

For rough part

$v^2 = u^2 + 2as$

$0 = v^2 + 2g(\sin\phi - \mu\cos\phi)s$

$\cancel{2gs} \cdot \sin\phi = -\cancel{2gs}(\sin\phi - \mu\cos\phi)$

$\sin\phi = -\sin\phi + \mu\cos\phi$

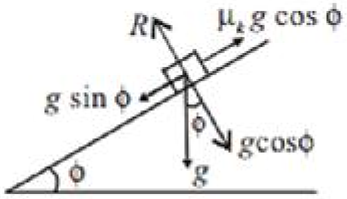
$2\sin\phi = \mu\cos\phi$

$\boxed{\mu = 2\tan\phi}$

PQ4S137

Ans [A]

For upper half smooth incline, component of g down the incline = $g\sin\phi$



$$\therefore \; v^2 = 2(g\sin\phi)\,\frac{l}{2}$$

For lower half rough incline, frictional retardation = $\mu_k g\cos\phi$

$\therefore$ Resultant acceleration = $g\sin\phi - \mu_k g\cos\phi$

$$\therefore \; 0 = v^2 + 2\,(g\sin\phi - \mu_k g\cos\phi)\frac{l}{2}$$

$$\text{or } 0 = 2(g\sin\phi)\,\frac{l}{2} + 2g(\sin\phi - \mu_k\cos\phi)\,\frac{l}{2}$$

$$\text{or } 0 = \sin\phi + \sin\phi - \mu_k\cos\phi$$

or $\mu_k \cos\phi = 2\sin\phi$

or $\mu_k = 2\tan\phi$

By equation of motion

$v^2 = u^2 + 2as$

consider initial velocity as 0.

a for smooth incline = $g\sin\Phi$

a for rough incline = $g\sin\Phi$ - $\mu g\cos\Phi$

where Φ is angle of inclination

PQ4Q138

A bullet fired into a fixed target loses half its velocity after penetrating 3 cm. How much further it will penetrate before coming to rest assuming that it faces constant resistance to motion?

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(A) 1.5 cm (B) 1.0 cm

(C) 3.0 cm (D) 2.0 cm

$$v^2 = u^2 + 2as$$

$$\left(\frac{u}{2}\right)^2 = u^2 + 2a(3)$$

$$\frac{u^2}{4} - u^2 = 6a$$

$$-\frac{\cancel{3}u^2}{4} = \overset{2}{\cancel{6}}a$$

$$0 = \left(\frac{u}{2}\right)^2 + 2as'$$

$$0 = \frac{u^2}{4} - \frac{u^2}{4}s'$$

$$s'\frac{\cancel{u^2}}{\cancel{4}} = \frac{\cancel{u^2}}{\cancel{4}} \Rightarrow s' = 1\ \text{cm}$$

PQ4S138

Ans [B]

For first part of penetration, by equation of motion,

$$\left(\frac{u}{2}\right)^2 = (u)^2 - 2f(3)$$

or $3u^2 = 24\ f$ .... (i)

For latter part of penetration,

$$0 = \left(\frac{u}{2}\right)^2 - 2fx$$

or $u^2 = 8fx$ .... (ii)

From (i) and (ii)

$3 \times (8\ fx) = 24\ f$

or $x = 1$ cm

By equation of motion

$v^2 = u^2 + 2as$

here a is acceleration and for retardation we'll use -a

PQ4Q139

A particle of mass 0.3 kg is subjected to a force F = – kx with k = 15 N/m. What will be its initial acceleration if it is released from a point 20 cm away from the origin?

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(A) 5 m/s^2

(B) 10 m/s^2

(C) 3 m/s^2

(D) 15 m/s^2

$$F = -15\left(\frac{2\cancel{0}}{10\cancel{0}}\right) = -3\ N$$

$$a = \frac{F}{m} = \frac{3}{0.3}$$

$$= 10\ m/s^2$$

PQ4S139

Ans [B]

F = – kx

$$\text{or } F = -15 \times \left(\frac{20}{100}\right) = -3N$$

Initial acceleration is over come by retarding force.

or m × (acceleration a) = 3

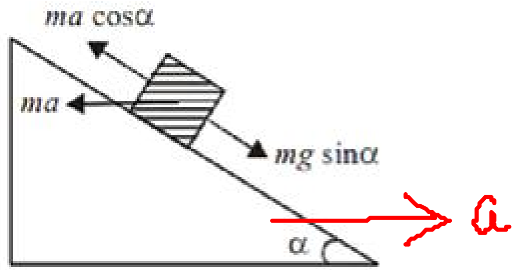
$$\text{or } a = \frac{3}{m} = \frac{3}{0.3} = 10\ \text{ms}^{-2}$$

Given F = kx

And F = ma (where m is the mass of the body and a is the acceleration of the body)

PQ4Q140

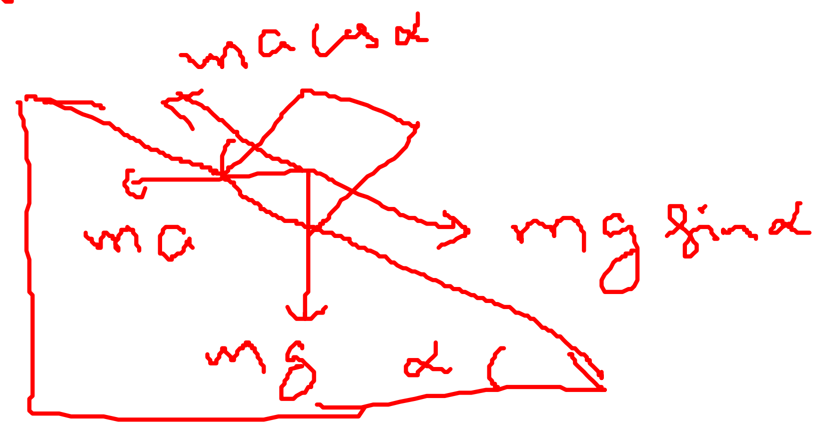
A block is kept on a frictionless inclined surface with angle of inclination α. The incline is given an acceleration a to keep the block stationary. Then a is equal to **AIEEE - 2005**



(A) g (B) gtanα

(C) g/tanα (D) gcosecα

w.r.t. inclined surface



$\cancel{m} a \cos\alpha = \cancel{m} g \sin\alpha$

$a = g \tan\alpha$

PQ4S140

Ans [B]

The incline is given an acceleration a. Acceleration of the block is to the right. Pseudo acceleration a acts on block to the left. Equate resolved parts of a and g along incline.

$\therefore$ $ma\cos\alpha = mg\sin\alpha$

or $a = g\tan\alpha$.

In the reference frame of the wedge, pseudo force ma acts towards right and component of this ma is $ma\cos\alpha$ balances the $mg\sin\alpha$.

$$mg\sin\alpha = ma\cos\alpha$$

PQ4Q141

Consider a car moving on a straight road with a speed of 100 m/s. The distance at which car can be stopped is [$\mu_k = 0.5$]

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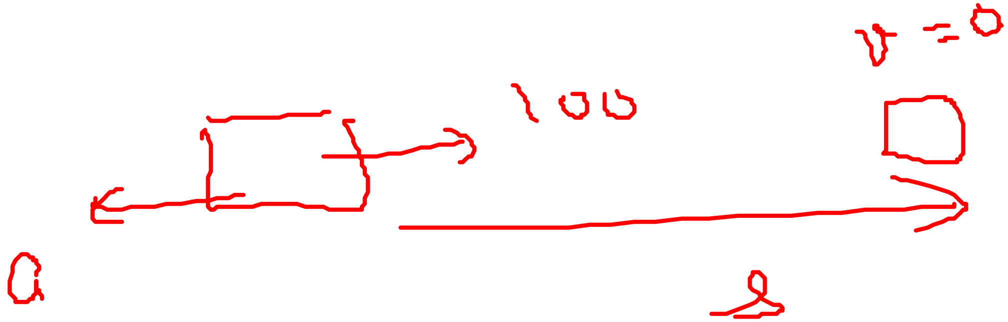
(A) 100 m

(B) 400 m

(C) 800 m

(D) 1000 m



$$a = \frac{f_k}{m} = \frac{\mu \cancel{m} g}{\cancel{m}}$$

$$= 5\ m/s^2$$

$$v^2 = u^2 + 2as$$

$$0 = (100)^2 - 2(5)s$$

$$s = \frac{100 \times 10\cancel{0}}{1\cancel{0}}$$

$$= 1000\ m$$

PQ4S141

Ans [D]

Retardation due to friction = μg

$\because \; v^2 = u^2 + 2as$

$\therefore \; 0 = (100)^2 - 2(\mu g)s$

or $2 \mu g s = 100 \times 100$

$$\text{or } s = \frac{100 \times 100}{2 \times 0.5 \times 10} = 1000 \text{ m}$$

By equation of motion

$v^2 = u^2 = 2as$ also

$a = \mu g$

PQ4Q142

A player caught a cricket ball of mass 150 g moving at a rate of 20 m/s. If the catching process is completed in 0.1 s, the force of the blow exerted by the ball on the hand of the player is equal to

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(A) 300 N (B) 150 N

(C) 3 N (D) 30 N

$$F = \frac{\Delta p}{\Delta t} = \frac{mv}{\Delta t} = \frac{0.15 \times 2\cancel{0}}{0.1}$$

$$= 30 N$$

PQ4S142

Ans [D]

Force $\times$ Time = Impulse = Change of momentum

$$\therefore \text{Force} = \frac{\text{Impulse}}{\text{Time}} = \frac{3}{0.1} = 30 \text{ N.}$$

Impulse = Change in momentum

Force = Impulse / Time