Question1

If the breaking strength of a rope is $\frac{4}{3}$ times the weight of a person, then the maximum acceleration with which the person can safely climb up the rope is (g = acceleration due to gravity)

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Options:

A.

$\frac{g}{2}$

B.

g

C.

$\frac{g}{3}$

D.

$\frac{2g}{3}$

Answer: C

Solution:

Breaking strength of string is $\frac{4}{3}$ times weight of person

So, maximum tension with stand by string

$T = \frac{4}{3}W = \frac{4}{3}mg$

Now, for maximum acceleration while climbing up;

$$T - mg = ma$$
$$\frac{4}{3}mg - mg = ma$$
$$a = \frac{4}{3}g - g = \frac{g}{3}$$

Question2

A block of mass 2 kg is placed on a rough horizontal surface. If a horizontal force of 20 N acting on the block produces an acceleration of 7 ms^{-2} in it, then the coefficient of kinetic friction between the block and the surface is

(Acceleration due to gravity $= 10 \text{ ms}^{-2}$)

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Options:

A.

0.2

B.

0.3

C.

0.4

D.

0.5

Answer: B

Solution:

$$F - f_k = ma$$
$$\Rightarrow \quad 20 - f_k = 2 \times 7$$
$$\Rightarrow \quad f_k = 6 \Rightarrow \mu_k N = 6$$
$$\Rightarrow \quad \mu_k = \frac{6}{N} = \frac{6}{mg} = \frac{6}{2 \times 10} = 0.3$$

Question3

Two bodies A and B of masses 1.5 kg and 3 kg are moving with velocities 20 ms^{-1} and 15 ms^{-1} respectively. If the same retarding force is applied on the two bodies, then the ratio of the distances travelled by the bodies A and B before they come to rest is

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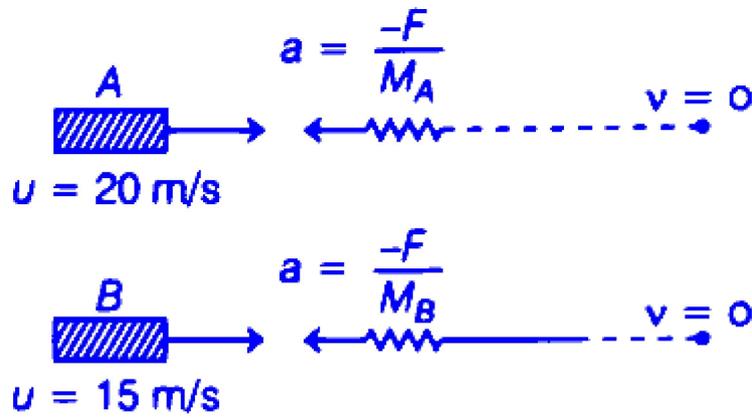
Options:

A.

1 : 1

B.

8 : 9

C.

2 : 3

D.

3 : 8

Answer: B

Solution:

Let S = displacement of body beforce coming to rest

Then using,

$$v^2 - u^2 = 2aS$$

we get,

$$-u^2 = 2\left(\frac{-F}{m}\right)S$$

$or\ S = \dfrac{u^2 m}{2F}$ or $S \propto u^2 m$

(for same retarding force F)

$\therefore \quad \dfrac{S_A}{S_B} = \dfrac{u_A^2 m_A}{u_B^2 m_B} = \dfrac{400 \times 1.5}{225 \times 3} = \dfrac{8}{9}$

Question4

Two blocks A and B of masses 2 kg and 4 kg respectively are kept on a rough horizontal surface. If same force of 20 N is applied on each block, then the ratio of the accelerations of the blocks A and B is (Coefficient of kinetic friction between the surface and the blocks is 0.3 and acceleration due to gravity $= 10 \text{ ms}^{-2}$)

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Options:

A.

1 : 1

B.

7 : 2

C.

1 : 2

D.

4 : 3

Answer: B

Solution:

Step 1: Find the friction force for each block

The friction force is given by: $F_{friction} = \mu_k \times m \times g$

For block A (mass $= 2\,\text{kg}$):
$F_{KA} = 0.3 \times 2 \times 10 = 6\,\text{N}$

For block B (mass $= 4\,\text{kg}$):
$F_{KB} = 0.3 \times 4 \times 10 = 12\,\text{N}$

Step 2: Find the net force on each block

The net force is the applied force minus friction:

For block A:
$F_A = 20 - 6 = 14\,\text{N}$

For block B:
$F_B = 20 - 12 = 8\,\text{N}$

Step 3: Find the acceleration of each block

Use $a = \frac{F_{net}}{m}$ for each block.

For block A:
$a_A = \frac{14}{2} = 7\,\text{m/s}^2$

For block B:
$a_B = \frac{8}{4} = 2\,\text{m/s}^2$
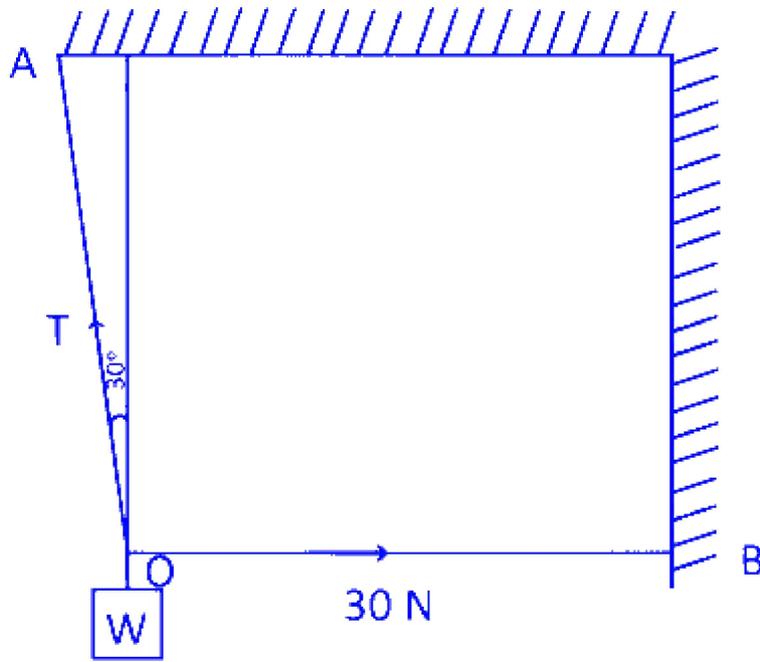
Step 4: Find the ratio of accelerations

$\frac{a_A}{a_B} = \frac{7}{2}$ So, the ratio is $7 : 2$.

Question5

If the tension in the horizontal wire shown in the figure is 30 N , then the weight W and tension in the wire OA are respectively

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Options:
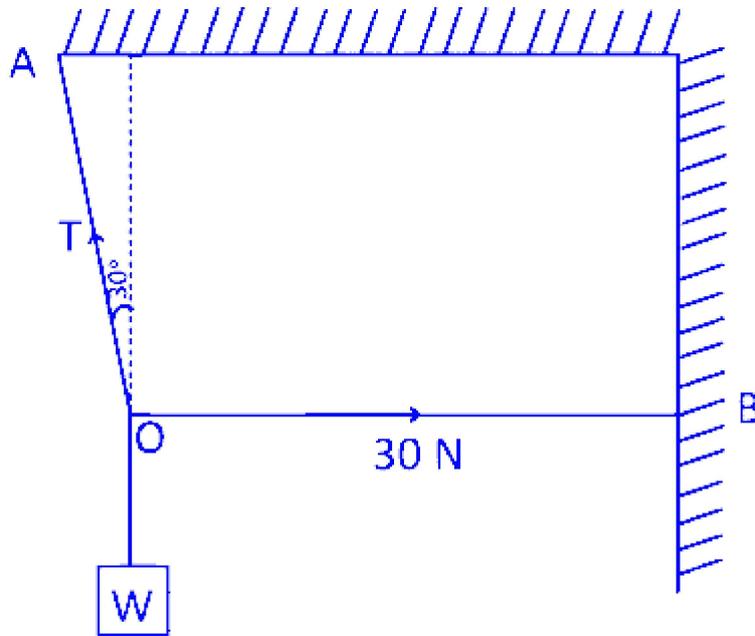
A.

$30\sqrt{3}$ N, 30 N

B.

$30\sqrt{3}$ N, 60 N

C.

$60\sqrt{3}$ N, 30 N

D.

$60\sqrt{3}$ N, 60 N

Answer: B

Solution:

Using Lami's theorem

$$\frac{T}{\sin 90°} = \frac{30}{\sin(180° - 30°)} = \frac{W}{\sin(90° + 30°)}$$

$$\Rightarrow \quad T = \frac{30}{\sin 30°} = \frac{W}{\cos 30°}$$

$$\Rightarrow \quad T = 60 = \frac{2W}{\sqrt{3}}$$

$$\therefore \quad T = 60 \text{ N}$$

$$\frac{2W}{\sqrt{3}} = 60 \Rightarrow W = 30\sqrt{3} \text{ N}$$

Question6

A balloon with mass ' m ' is descending vertically with an acceleration ' a ' (where $a

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Options:

A.

$\frac{ma}{g+a}$

B.

$\frac{ma}{g-a}$

C.

$$\frac{2ma}{g+a}$$

D.

$$\frac{2ma}{g-a}$$

Answer: C

Solution:

When the balloon is descending, the net force acting on it is given by $F_{\text{net}} = mg - B = ma$, where B is the Buoyant force.

Thus, $B = mg - ma$ $\qquad \ldots (i)$

For the balloon to move upwards with the same acceleration a, a mass Δm must be removed. The new net force equation becomes

$$B - (m - \Delta m)g = (m - \Delta m)a$$
$$mg - ma - (m - \Delta m)g = (m - \Delta m)a \quad [From Eq.\,(i)]$$

$\Rightarrow \quad \Delta m = \frac{2ma}{g+a}$

Question7

A conveyor belt is moving horizontally with a velocity of $2\,\text{ms}^{-1}$. If a body of mass 10 kg is kept on it, then the distance travelled by the body before coming to rest is

(The coefficient of kinetic friction between the belt and the body is 0.2 and acceleration due to gravity is $10\,\text{ms}^{-2}$)

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Options:

A.

4 m

B.

0 m

C.

1 m

D.

2 m

Answer: C

Solution:

Frictional force

$$f_s = \mu mg = 0.2 \times 10 \times 10$$
$$\Rightarrow \quad f_s = 20 \text{ N}$$

$\therefore$ deceleration, $a = \frac{f_s}{m}$

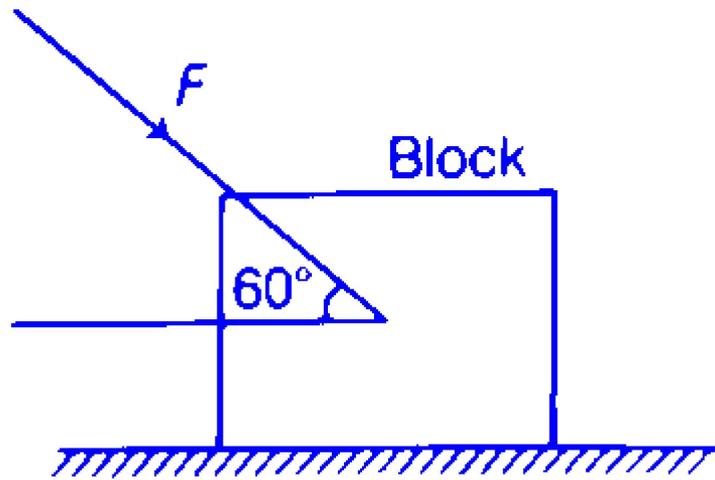$$= \frac{20}{10} = 2 \text{ m/s}^2$$

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

$$\Rightarrow \quad s = \frac{v^2 - u^2}{2a}$$
$$= \frac{0^2 - 2^2}{2 \times (-2)} = 1 \text{ m}$$

Question8

As shown in the figure, a force F is applied on a block of mass $\sqrt{3}$ kg placed on a rough horizontal surface. The maximum value of F for the block not to move is (Coefficient of static friction between the block and the

surface is $\frac{1}{2\sqrt{3}}$ and acceleration due to gravity $= 10 \text{ ms}^{-2}$)

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Options:

A.

5 N

B.

10 N

C.

15 N

D.

20 N

Answer: D

Solution:

Maximum static friction

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

For the block not to move,

$F \cos 60° = (f_s)_{\max}$
$F \cos 60° = \mu_s N$

$F \cos 60° = \mu_s (mg + F \sin 60°)$

$\Rightarrow F \times \dfrac{1}{2} = \dfrac{1}{2\sqrt{3}} \left(\sqrt{3} \times 10 + F\dfrac{\sqrt{3}}{2} \right)$

$\Rightarrow \quad F = \dfrac{1}{\sqrt{3}} \left(10\sqrt{3} + \dfrac{F\sqrt{3}}{2} \right)$

$\Rightarrow \quad F = 10 + \dfrac{F}{2}$

$\Rightarrow \quad F - \dfrac{F}{2} = 10$

$\quad F = 20 \text{ N}$

Question9

A balloon carrying some sand of mass M is moving down with a constant acceleration a_0. The mass m of sand to be removed, so that the balloon moves up with double the acceleration a_0 is

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Options:

A. $m = \dfrac{2Ma_0}{a_0 + g}$

B. $m = \dfrac{2Ma_0}{a_0 - g}$

C. $m = \dfrac{3Ma_0}{g + 2a_0}$

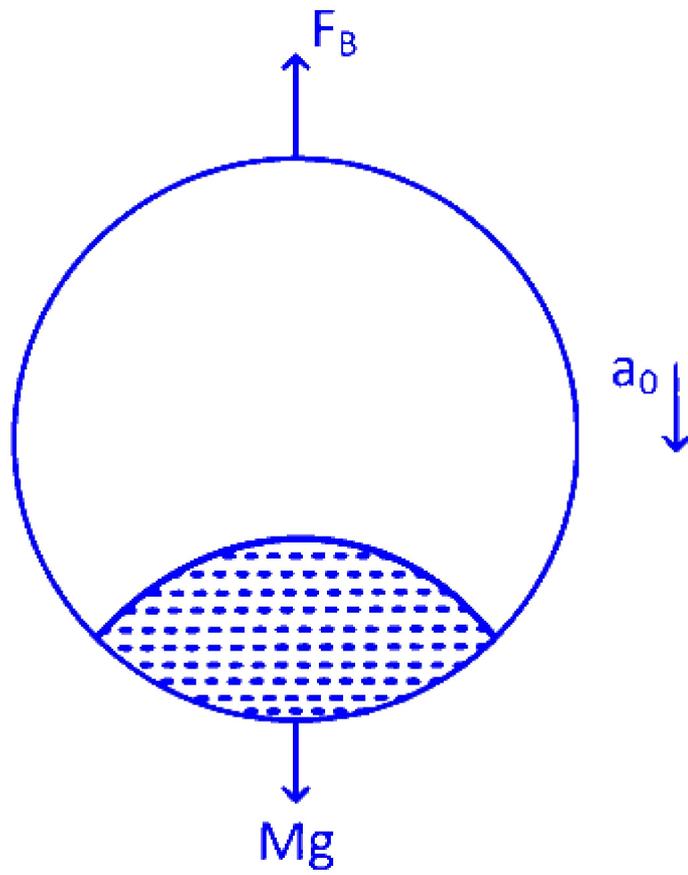D. $m = \dfrac{3Ma_0}{g - 2a_0}$
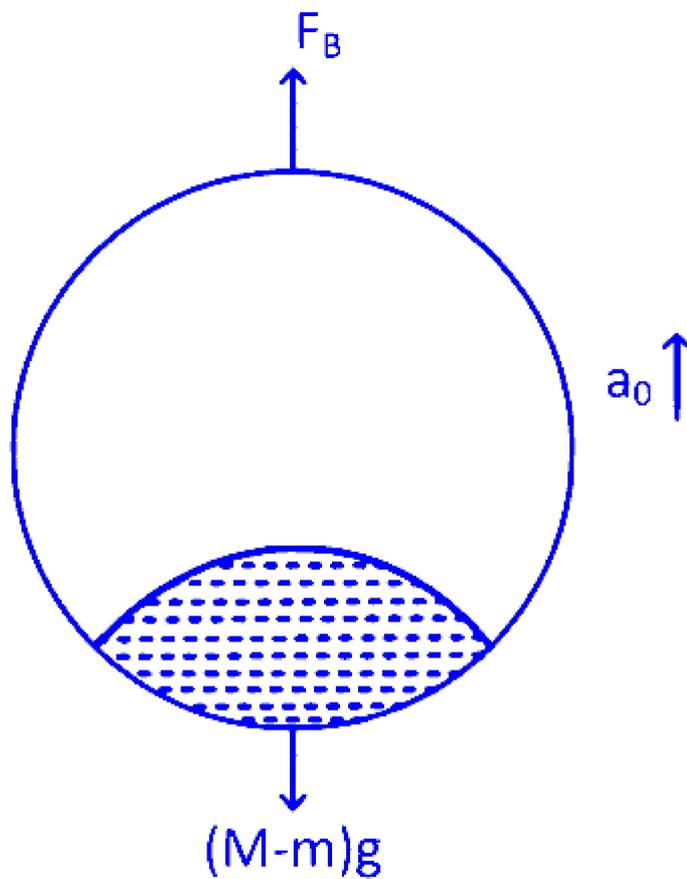
Answer: C

Solution:

Case-1 $Mg - F_B = Ma_0 \qquad \dots(i)$

Case-2

Let removed mass is m.

$$\therefore \quad F_B - (M-m)g = (M-m)2a_0 \qquad \dots(ii)$$

Adding Eqs. (i) and (ii), we get

$$Mg - (M-m)g = Ma_0 + (M-m) \cdot 2a_0$$
$$\Rightarrow \quad g[M - M + m] = a_0(M + 2M - 2m)$$
$$\Rightarrow \quad gm = a_0(3M - 2m)$$
$$\Rightarrow \quad gm + 2ma_0 = 3Ma_0$$
$$\Rightarrow \quad m(g + 2a_0) = 3Ma_0 \Rightarrow m = \frac{3Ma_0}{g + 2a_0}$$

Question10

The acceleration of a body sliding down the inclined plane, having coefficient of friction μ is

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Options:

A. $a = g(\sin\theta + \mu\cos\theta)$

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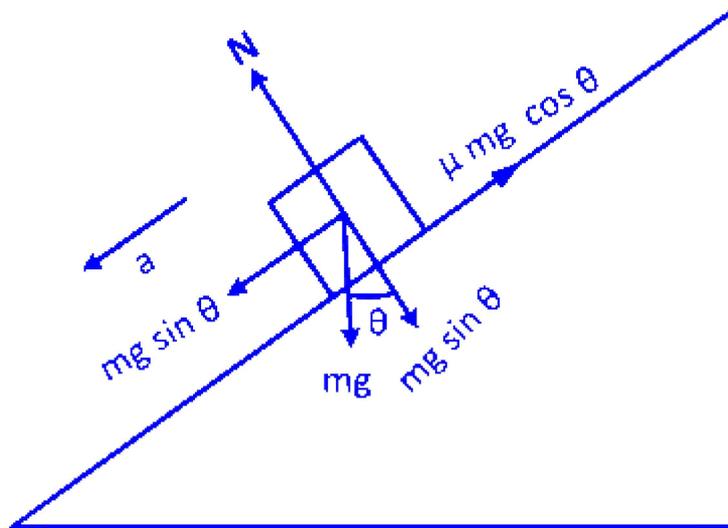
C. $a = g(\sin\theta - \mu\cos\theta)$

D. $a = g(\cos\theta + \mu\sin\theta)$

Answer: B

Solution:

According to figure, the net force F_{net} acting downward in inclined plane is the difference between the component of the gravitational force parallel to the plane and the frictional force.

$$F_{\text{net}} = mg\sin\theta - \mu mg\cos\theta$$

Using Newton's second law,

$$F_{\text{net}} = m \cdot a$$
$$a = \frac{F_{\text{net}}}{m}$$

Putting value of F_{net},

$$a = \frac{mg\sin\theta - \mu mg\cos\theta}{m}$$
$$a = g\sin\theta - \mu g\cos\theta$$
$$a = g(\sin\theta - \mu\cos\theta)$$

Question11

A body of 2 kg mass slides down with an acceleration of $4\ \text{ms}^{-2}$ on an inclined plane having slope of $30°$. The external force required to take the same body up the plane with same acceleration will be (acceleration due to gravity $= 10\ \text{ms}^{-2}$)

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Options:

A. 8 N

B. 16 N

C. 22 N

D. 20 N

Answer: D

Solution:

To calculate the external force required to push a 2 kg mass up an inclined plane at an acceleration of $4\,\mathrm{ms}^{-2}$, we first need to understand the forces at play when the body moves down the plane.

When sliding down:

The net force (F_{net}) is given by:

$$F_{\text{net}} = mg\sin\theta - f$$

Applying Newton's second law $F_{\text{net}} = ma$, we have:

$$ma = mg\sin\theta - f$$

Given values:

$$m = 2\,\mathrm{kg}$$

$$a = 4\,\mathrm{ms}^{-2}$$

$$g = 10\,\mathrm{ms}^{-2}$$

$$\theta = 30°$$

By substituting these values:

$$2 \times 4 = 2 \times 10 \times \sin 30° - f$$

Evaluating further gives:

$$8 = 20 \times 0.5 - f$$

$$f = 10 - 8 = 2\,\mathrm{N}$$

When the body is sliding up the inclined plane, the required force F is determined by:

Modifying the net force equation for the upward motion, we have:

$$F - mg\sin\theta - f = ma$$

Rearranging gives:

$$F = ma + mg\sin\theta + f$$

Substituting the values:

$F = 2 \times 4 + 2 \times 10 \times \sin 30° + 2$

$F = 8 + 10 + 2 = 20\,\text{N}$

Therefore, the force required to take the body up with the same acceleration is $20\,\text{N}$.

Question12

A 100 kg cannon fires a ball of 1 kg horizontally from a cliff of height 500 m . It falls on the ground at a distance of 400 m from the bottom of the cliff. The recoil velocity of the gun is (Acceleration due to gravity $= 10\,\text{ms}^{-2}$)

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Options:

A. $0.6\,\text{ms}^{-1}$

B. $0.8\,\text{ms}^{-1}$

C. $0.2\,\text{ms}^{-1}$

D. $0.4\,\text{ms}^{-1}$

Answer: D

Solution:

Given:

Mass of the gun, $M = 100\,\text{kg}$

Mass of the ball, $m = 1\,\text{kg}$

Height of the cliff, $h = 500\,\text{m}$

Distance from the cliff to where the ball lands, $s = 400\,\text{m}$

Acceleration due to gravity, $g = 10\,\text{m/s}^2$

Step 1: Calculate Time of Flight

The time taken by the ball to fall to the ground can be determined using the formula for the time of free fall:

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 500}{10}} = \sqrt{100} = 10 \, \text{s}$$

Step 2: Determine Horizontal Velocity

The horizontal distance covered by the ball is given by $s = u \times t$, where u is the horizontal velocity of the ball:

$$s = u \times t$$
$$400 = u \times 10$$
$$u = 40 \, \text{m/s}$$

Step 3: Apply Conservation of Linear Momentum

Initially, the system (cannon + ball) is at rest, so the initial momentum is zero. After the ball is fired, by the conservation of linear momentum, the total momentum should still be zero:

$$0 = Mv + mu$$

Solving for the recoil velocity v of the gun, we have:

$$Mv = -mu$$
$$v = -\frac{mu}{M} = -\frac{(1) \times (40)}{100}$$
$$v = -0.4 \, \text{m/s}$$

The negative sign indicates that the recoil velocity of the gun is opposite in direction to the velocity of the ball. Thus, the recoil velocity of the gun is 0.4 m/s.

Question13

A block of mass 5 kg is placed on a rough horizontal surface having coefficient of friction 0.5 . If a horizontal force of 60 N is acting on it, then the acceleration of the block is (Acceleration due ot gravity, $g = 10 \, \text{ms}^{-2}$)

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Options:

A. $7 \, \text{ms}^{-2}$

B. $5 \, \text{ms}^{-2}$

C. $10 \, \text{ms}^{-2}$

D. 15 ms^{-2}

Answer: A

Solution:

To find the acceleration of the block, we start with the given values:

Mass of the block, $m = 5 \text{ kg}$

Coefficient of friction, $\mu = 0.5$

Horizontal force applied, $F_H = 60 \text{ N}$

Acceleration due to gravity, $g = 10 \text{ m/s}^2$

First, calculate the frictional force (F_f) using the formula:

$$F_f = \mu \times N = \mu \times m \times g$$

Substitute the values:

$$F_f = 0.5 \times 5 \times 10$$

$$F_f = 25 \text{ N}$$

Now, compute the net force (F_{net}) acting on the block by subtracting the frictional force from the horizontal force:

$$F_{\text{net}} = F_H - F_f$$

$$F_{\text{net}} = 60 - 25 = 35 \text{ N}$$

Finally, calculate the acceleration (a) of the block using Newton's second law:

$$a = \frac{F_{\text{net}}}{m}$$

$$a = \frac{35}{5}$$

$$a = 7 \text{ m/s}^2$$

Therefore, the acceleration of the block is 7 m/s^2.

Question14

A block of metal 4 kg is in rest on a frictionless surface. It was targeted by a jet releasing water of 2 kg s^{-1} at a speed of 10 ms^{-1}. The acceleration of the block is

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Options:

A. 10 ms^{-2}

B. 15 ms^{-2}

C. 20 ms^{-2}

D. 5 ms^{-2}

Answer: D

Solution:

Given the following information:

Mass of the block (m) = 4 kg

Rate of water release $\left(\frac{dm}{dt} \right)$ = 2 kg/s

Speed of the water (v) = 10 m/s

To find the acceleration of the block, start by calculating the force exerted on it. The force (F) can be calculated using the relationship:

$F = \frac{dm}{dt} \cdot v$

Substitute the given values:

$F = 2 \times 10 = 20 \, \text{N}$

Next, use Newton's second law to find the acceleration (a) of the block. The relationship between force, mass, and acceleration is:

$F = m \cdot a$

Rearranging for acceleration gives:

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

Plug in the calculated force and the mass of the block:
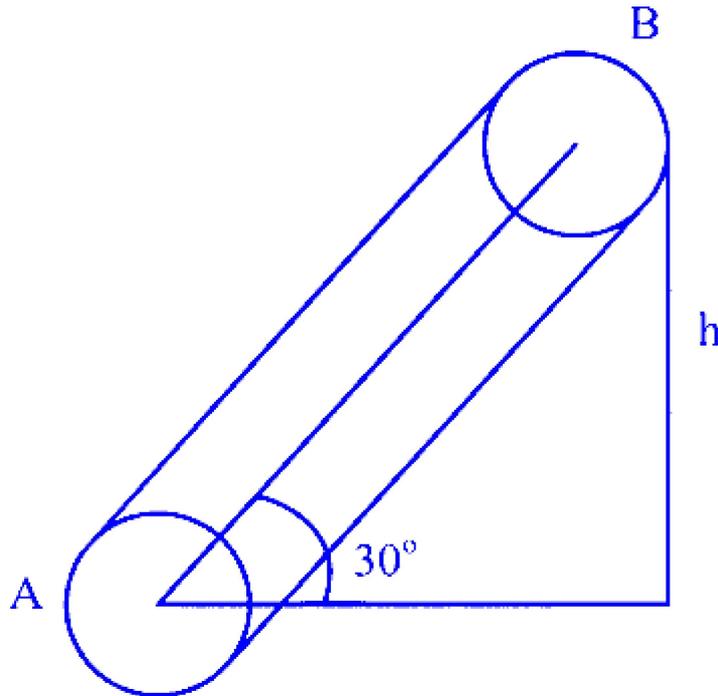
$a = \frac{20}{4} = 5 \, \text{m/s}^2$

Therefore, the acceleration of the block is $5 \, \text{m/s}^2$.

Question15

A person climbs up a conveyor belt with a constant acceleration. The speed of the belt is $\sqrt{\frac{gh}{6}}$ and coefficient of friction is $\frac{5}{3\sqrt{3}}$. The time taken by the person to reach from A to B with maximum possible acceleration is

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Options:

A. $\sqrt{\frac{hg}{6}}$

B. $\sqrt{6gh}$

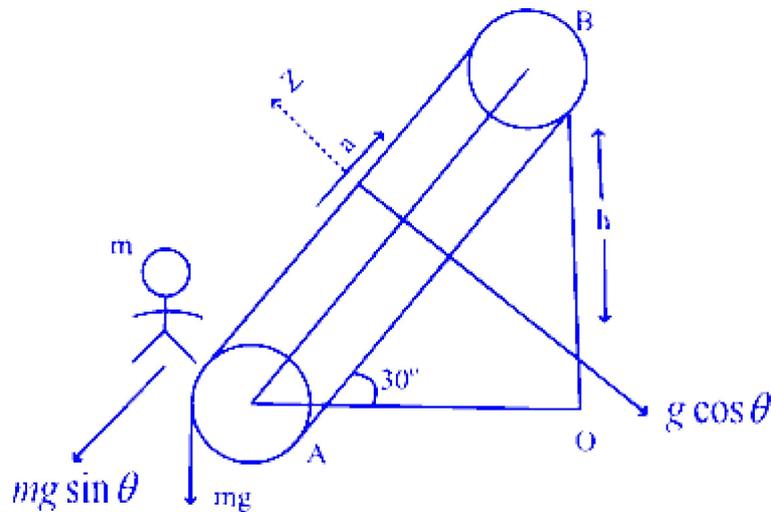C. $\sqrt{\frac{2h}{g}}$

D. $\sqrt{\frac{6h}{g}}$

Answer: D

Solution:

Given:

The angle of inclination, $\theta = 30°$.

The speed of the conveyor belt, $v_{\text{belt}} = \sqrt{\frac{gh}{6}}$.

The coefficient of friction, $\mu = \frac{5}{3\sqrt{3}}$.

Calculation of Maximum Possible Acceleration:

The maximum force of friction that can act on the person while climbing is given by:

$$F_{\text{max}} = \mu mg \cos \theta$$

The component of gravitational force acting parallel to the incline is:

$$F_{\text{parallel}} = mg \sin \theta$$

Using Newton's second law, the maximum acceleration a is:

$$a = \frac{F_{\text{max}} - F_{\text{parallel}}}{m}$$

Substitute the given values:

$$a = \frac{\mu mg \cos \theta - mg \sin \theta}{m}$$
$$= \frac{\frac{5}{3\sqrt{3}} mg \times \frac{\sqrt{3}}{2} - mg \times \frac{1}{2}}{m}$$
$$= \frac{\frac{5}{6} mg - \frac{1}{2} mg}{m}$$
$$= \frac{g}{3}$$

Solving for Time t:

The displacement from point A to point B is $AB = \frac{OB}{\sin \theta} = \frac{h}{1/2} = 2h$. The equation of motion is:

$$AB = v_{\text{belt}} \cdot t + \frac{1}{2} a t^2$$

Substituting the known values, we have:

$$2h = \sqrt{\frac{gh}{6}} \cdot t + \frac{1}{2} \cdot \frac{g}{3} \cdot t^2$$

$$= \sqrt{\frac{gh}{6}} \cdot t + \frac{g}{6} \cdot t^2$$

Reorganizing terms gives:

$$2h = \sqrt{\frac{gh}{6}} \cdot t + \frac{g}{6} \cdot t^2$$

Solving this quadratic equation in terms of t, we find:

$$t = \sqrt{\frac{6h}{g}}$$

Thus, the time taken for the person to travel from A to B with maximum possible acceleration is:

$$t = \sqrt{\frac{6h}{g}}$$

Question16

A block of metal 2 kg is in rest on a smooth plane. It is striked by a jet releasing water of 1 kg s^{-1} at a speed of 5 m/s, then the acceteration of the block is

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Options:

A. 2 ms^{-2}

B. 2.5 ms^{-2}

C. 025 ms^{-2}

D. 50 ms^{-2}

Answer: B

Solution:

Given:

Flow of water: $q = 1 \text{ kg/s}$

Speed of water: $v = 5 \text{ m/s}$

Mass of block: $m = 2 \text{ kg}$

The rate of momentum transfer can be calculated as:

$\frac{dp}{dt} = q \times v$

Substituting the given values:

$\frac{dp}{dt} = 1 \times 5 = 5 \, \text{kg m/s}^2$

This rate of change of momentum is equivalent to the force F exerted by the water jet on the block. Thus, we have:

$F = \frac{dp}{dt} = 5 \, \text{N}$

From Newton's second law, the force is also expressed as:

$F = m \times a$

Substituting the known values:

$2 \times a = 5$

Solving for a (acceleration of the block):

$a = \frac{5}{2} = 2.5 \, \text{m/s}^2$

Therefore, the acceleration of the block is $2.5 \, \text{m/s}^2$.

Question17

An insect is crawling in a hemi-spherical bowl of radius R. If the coefficient of friction between the insect and bowl is μ, then the maximum height to which the insect can crawl the bowl is

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Options:

A. $R \left[1 - \frac{1}{\sqrt{1+\mu^2}} \right]$

B. $R \left[1 + \frac{1}{\sqrt{1+\mu^2}} \right]$

C. $R \left[\frac{1}{\sqrt{1+\mu^2}} \right]$

D. $R \left[\frac{1}{\sqrt{1-\mu^2}} \right]$
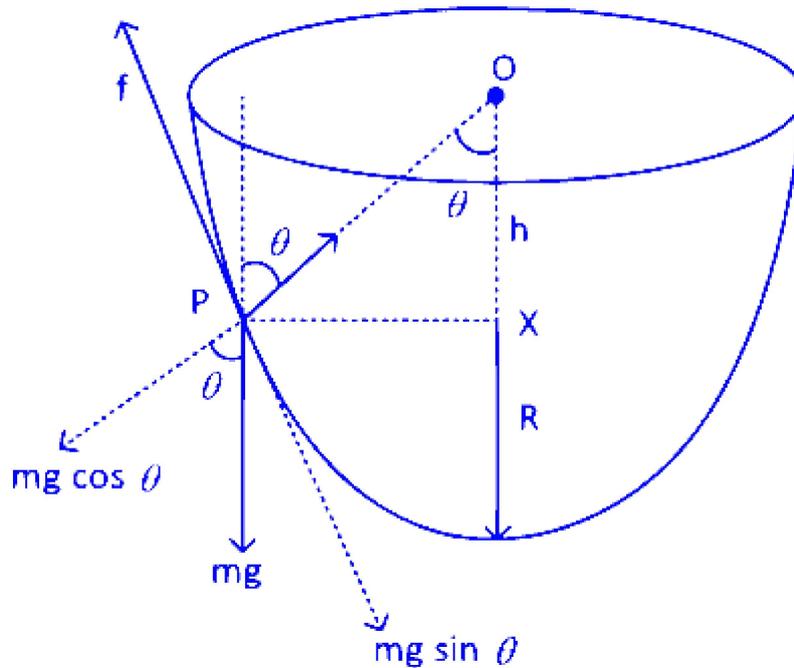
Answer: A

Solution:

Drawing the FBD according to question.

Insect is at highest point, (let it be in equilibrium)

$N = mg\cos\theta \quad \dots$ (i)

and $f = mg\sin\theta \quad \dots$ (ii)

For limiting case of static friction,

$$f = \mu N$$
$$\Rightarrow \quad mg\sin\theta = \mu mg\cos\theta \quad \dots \text{(iii)}$$
$$\therefore \quad \mu = \tan\theta$$

From above relation, $\cos\theta = \dfrac{1}{\sqrt{\mu^2+1}}$

$\left[\text{Identity used,} \ \cos\theta = \dfrac{1}{\sqrt{\tan^2\theta+1}} \right]$

In $\triangle OXP$

$$\cos\theta = \dfrac{R-h}{R}$$
$$\therefore \quad \dfrac{R-h}{R} = \dfrac{1}{\sqrt{u^2+1}}$$
$$\therefore \quad h = R\left[1 - \dfrac{1}{\sqrt{\mu^2+1}}\right]$$

Question18

Two objects having masses $1:4$ ratio are at rest. When both of them are subjected to same force separately, they achieved same kinetic

energy during times t_1 and t_2 respectively. Then, ratio of $\frac{t_2}{t_1}$ is

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Options:

A. 4

B. 2

C. 2.5

D. 1

Answer: B

Solution:

Given that the mass ratio of the two objects is $\frac{m_1}{m_2} = \frac{1}{4}$, when both objects are subjected to the same force, their acceleration relationship is given by:

$$m_1 a_1 = m_2 a_2 \implies \frac{m_2}{m_1} = \frac{a_1}{a_2} = \frac{4}{1}$$

The relation between velocity, acceleration, and time is:

$$v = u + at$$

For the objects starting from rest:

$$v_1 = 0 + a_1 t_1 = a_1 t_1$$

$$v_2 = 0 + a_2 t_2 = a_2 t_2$$

Given that the kinetic energies are equal:

$$K_1 = K_2 \implies \tfrac{1}{2} m_1 v_1^2 = \tfrac{1}{2} m_2 v_2^2$$

Substituting the velocities:

$$\tfrac{1}{2} m_1 (a_1 t_1)^2 = \tfrac{1}{2} m_2 (a_2 t_2)^2$$

This simplifies to:

$$\frac{m_1}{m_2} \left(\frac{a_1}{a_2} \right)^2 = \left(\frac{t_2}{t_1} \right)^2$$

Substituting the given ratios:

$$\tfrac{1}{4} \times \left(\tfrac{4}{1} \right)^2 = \left(\frac{t_2}{t_1} \right)^2$$

This results in:

$$\frac{t_2}{t_1} = 2$$

Question19

A block of mass 18.5 kg kept on a smooth horizontal surface is pulled by a rope of 3 m length by a horizontal force of 40 N applied to the other end of the rope. If the linear density of the rope is 0.5kgm^{-1} and initially the block is at rest, the time in which the block moves a distance of 9 m is
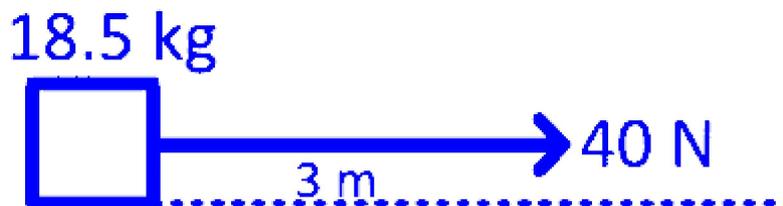
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Options:

A. 3 s

B. 5 s

C. 7 s

D. 9 s

Answer: A

Solution:

Given, Linear density of rope

$= 0.5 \text{ kg m}^{-1}$

So, mass of rope $\Rightarrow m = \lambda \cdot l$

$m = 0.5 \times 3 = 1.5 \text{ kg}$

$\therefore$ Total mass of system,

$m = 18.5 + 1.5 = 20 \text{ kg}$

Acceleration, $a = \frac{F}{m} = \frac{40}{20} = 2 \text{ m/s}^2$

Distance, $s = ut + \frac{1}{2}at^2$

$$s = \frac{1}{2}at^2 \quad (\because u = 0 \text{ given })$$

$$\frac{2 \times 9}{2} = t^2 \Rightarrow t = 3 \text{ s}$$

Question20

A block of mass 1.5 kg kept on a rough horizontal surface is given a horizontal velocity of $10 \mathrm{~ms}^{-1}$. If the block comes to rest after travelling a distance of 12.5 m , the coefficient of kinetic friction between the surface and the block is (acceleration due to gravity $= 10 \mathrm{~ms}^{-2}$)

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Options:

A. 0.2

B. 0.4

C. 0.8

D. 0.6

Answer: B

Solution:

Given:

Mass of the block (m) = 1.5 kg

Initial velocity (u) = 10 m/s

Distance traveled before coming to rest (s) = 12.5 m

Acceleration due to gravity (g) = 10 m/s^2

To find the coefficient of kinetic friction (μ_k), we first use the kinematic equation to determine the acceleration (a):

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

Since the block comes to rest, the final velocity (v) is 0. Plugging in the values:

$$0^2 = (10)^2 + 2 \times a \times 12.5$$

Solving for a:

$$-100 = 25a \quad \Rightarrow \quad a = -4\,\text{m/s}^2$$

The negative acceleration indicates that the block is decelerating due to friction. The force applied is equal to the frictional force, and we relate it to the coefficient of kinetic friction:

$$F = ma = -f$$

Where f is the frictional force, which is the product of the coefficient of kinetic friction (μ_k) and the normal force (N). Since the block is on a horizontal surface, the normal force (N) equals mg:

$$-f = \mu_k N \quad \Rightarrow \quad -\mu_k mg = ma$$

Rearranging the equation to solve for μ_k:

$$a = -\mu_k g \quad \Rightarrow \quad \mu_k = \frac{a}{g} = \frac{4}{10} = 0.4$$

Therefore, the coefficient of kinetic friction between the surface and the block is 0.4.

Question21

Three blocks of masses $2\,\text{m}$, $4\,\text{m}$ and 6 m are placed as shown in figure. If $\sin 37° = \frac{3}{5}$, $\sin 53° = \frac{4}{5}$, the acceleration of the system is
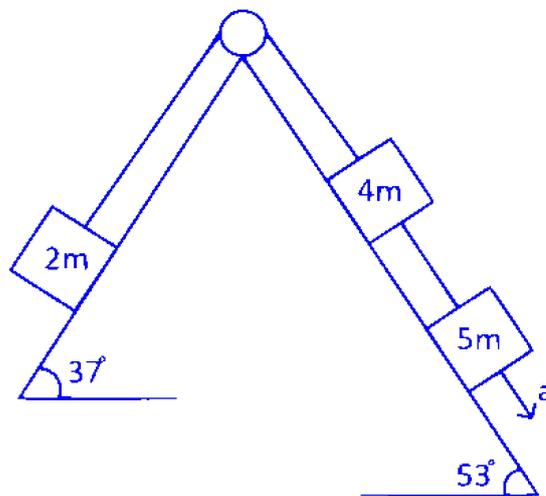
AP EAPCET 2024 - 18th May Morning Shift
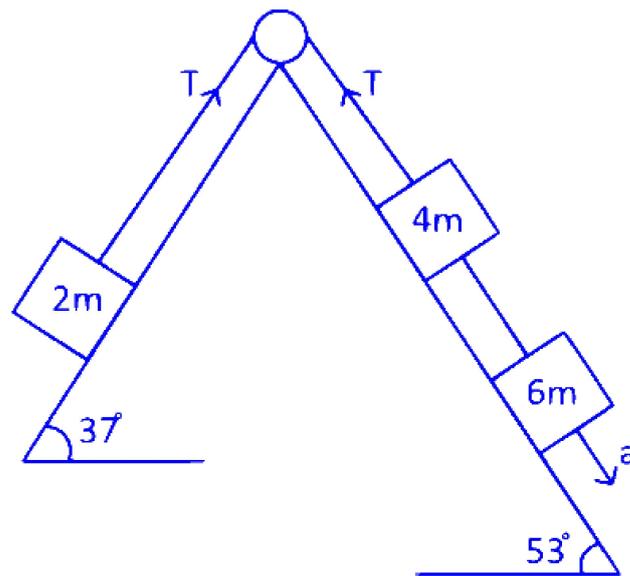
Options:

A. $a = \frac{17}{30}g$

B. $a = \frac{13}{30}g$

C. $a = \frac{13}{15}g$

D. $a = \frac{15}{35}g$

Answer: A

Solution:

According to figure, component of forces

$T - 2mg\sin 37° = 2ma$ ... (i)

$10mg\sin 53° - T = 10\text{ma}$ ... (ii)

Adding Eqs. (i) and (ii), we get

$10\text{mg}\sin 53° - 2mg\sin 37° = 12\text{ma}$

$10 \times g \times \frac{4}{5} - 2 \times g \times \frac{3}{5} = 12 \cdot a$

$\frac{34g}{5} = 12a$

$a = \frac{34g}{60}$

$a = \frac{17}{30}g$

Question22

Two masses m_1 and m_2 are connected by a light string passing over smooth pulley. When set free m_1 moves downwards by 3 m in 3 s. The ratio of $\frac{m_l}{m_2}$ is $\left(g = 10 \text{ ms}^{-2}\right)$
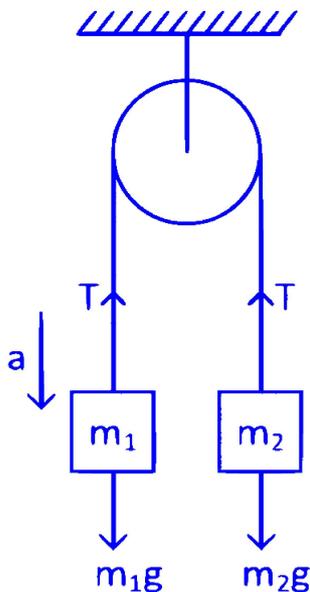
AP EAPCET 2024 - 18th May Morning Shift

Options:

A. $\frac{9}{7}$

B. $\frac{8}{7}$

C. $\frac{10}{7}$

D. $\frac{15}{13}$

Answer: B

Solution:

Given,

$s = 3 \text{ m}, t = 3 \text{ s}, u = 0(\text{ set free })$

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

$3 = 0 + \frac{1}{2}a \times 3^2$

$a = \frac{2}{3} \text{ m/s}^2$

Applying the result of Newton 2nd law,

$F = ma$

So, $m_1 g - T = m_1 a$ ... (i)
$T - m_2 g = m_2 a$ ... (ii)

Adding Eq. (i) and Eq. (ii),

$g(m_1 - m_2) = a(m_1 + m_2)$

$10(m_1 - m_2) = \dfrac{2}{3}(m_1 + m_2)$

$15 m_1 - 15 m_2 = m_1 + m_2$

$14 m_1 = 16 m_2$

$7 m_1 = 8 m_2$

$\dfrac{m_1}{m_2} = \dfrac{8}{7}$

Question23

A body is travelling with 10 ms^{-1} on a rough horizontal surface. It's velocity after 2 s is 4 ms^{-1}. The coefficient of kinetic friction between the block and the plane is (acceleration due to gravity $= 10 \text{ ms}^{-2}$)

AP EAPCET 2022 - 5th July Morning Shift

Options:

A. 0.4

B. 0.3

C. 0.5

D. 0.2

Answer: B

Solution:

Initial speed of body on the horizontal rough surfaces, $u = 10 \text{ ms}^{-1}$

Final velocity, $v = 4 \text{ ms}^{-1}$ and $t = 2$ s.

If a be the retardation due to friction, then by using equation,

$$v = u - at$$
$$\Rightarrow \quad 4 = 10 - a \times 2$$
$$\Rightarrow \quad 2a = 6 \Rightarrow a = 3 \text{ ms}^{-2}$$

According to given situation,

friction force $= ma$
$$\Rightarrow \mu_k mg = ma$$
$$\Rightarrow \mu_k = \frac{a}{g} = \frac{3}{10} = 0.3$$

Question24

A cricket ball of mass 50 g having velocity 50 cm s^{-1} to stopped in 0.5 s. The force applied to stop the ball is

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Options:

A. 0.07 N

B. 0.05 N

C. 5 N

D. 7 N

Answer: B

Solution:

Mass of cricket ball, $m = 50 \text{ g} = 0.05 \text{ kg}$

Initial velocity of ball, $u = 50\text{cms}^{-1} = 0.5 \text{ ms}^{-1}$

time, $t = 0.5 \text{ s}$

If a be the retardation applied on the cricket ball, then by using

$$v = u - at$$
$$\Rightarrow \quad 0 = 0.5 - a \times 0.5 \Rightarrow a = \frac{0.5}{0.5}$$
$$= 1 \text{ m/s}^2$$

Force applied,

$$F = \text{mass} \times \text{acceleration}$$
$$= 0.05 \times 1 = 0.05 \text{ N}$$

Question25

Two masses M_1 and M_2 are arranged as shown in the figure. Let a be the magnitude of the acceleration of the mass M_1. If the mass of M_1 is doubled and that of M_2 is halved, then the acceleration of the system is(Treat all surfaces as smooth; masses of pulley and rope are negligible)
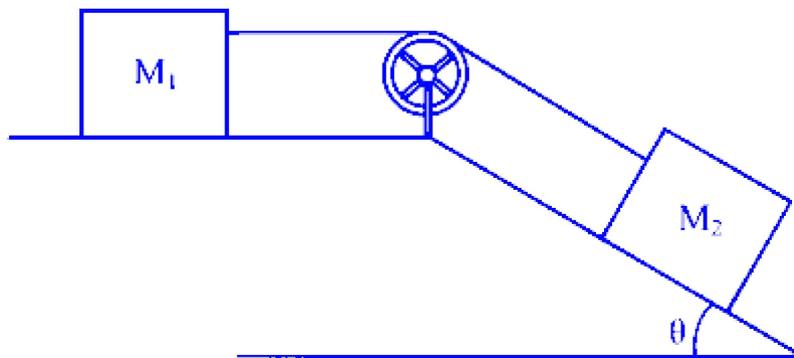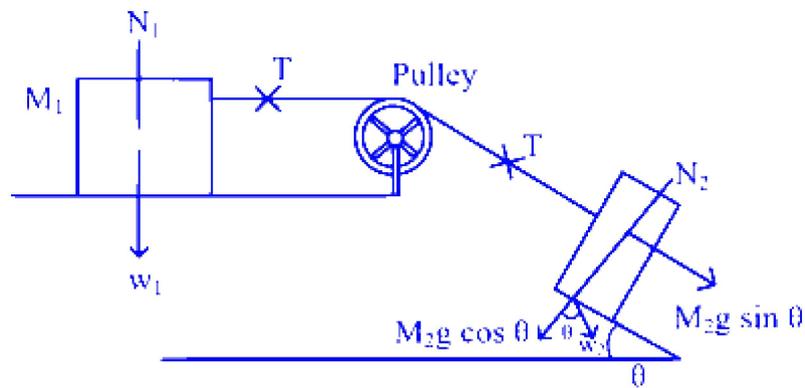

AP EAPCET 2022 - 4th July Evening Shift

Options:

A. $\left(\frac{M_1+M_2}{4M_1+M_2}\right)a$

B. $\left(\frac{2M_1+M_2}{4M_1+M_2}\right)a$

C. $\left(\frac{M_1+2M_2}{4M_1+2M_2}\right)a$

D. $\left(\frac{M_1+2M_2}{M_1+M_2}\right)a$

Answer: A

Solution:

FBD of the situation is given below.

From Newton's law, $\Sigma\mathbf{F} = $ ma

Force on M_1,

in x-direction, $T = M_1 a$ ... (i)

in y-direction, $N_1 - w_1 = 0$ .... (ii)

Similarly, forces on M_2,

in x-direction, $M_2 g \sin\theta - T = M_2 a$ .... (iii)

in y-direction, $N_2 - m_2 g \cos\theta = 0$ .... (iv)

Adding to eq. (i) with eq. (ii), we get

$$M_2 g \sin\theta = M_1 a + M_2 a$$
$$\Rightarrow \quad a = \frac{M_2 g \sin\theta}{M_1 + M_2}$$

According to question, when M_1 is doubled and M_2 is halved

$$a' = \frac{\frac{M_2}{2} g \sin\theta}{2M_1 + \frac{M_2}{2}} = \frac{M_2 g \sin\theta}{4M_1 + M_2}$$

Now, $\frac{a'}{a} = \frac{\frac{M_2 g \sin\theta}{4M_1 + M_2}}{\frac{M_2 g \sin\theta}{M_1 + M_2}} \Rightarrow a' = \left(\frac{M_1 + M_2}{4M_1 + M_2}\right) a$

Question26

Two rectangular blocks of masses 40 kg and 60 kg are connected by a string and kept on a frictionless horizontal table. If a force of 1000 N is applied on 60 kg block away from 40 kg block, then the tension in string is
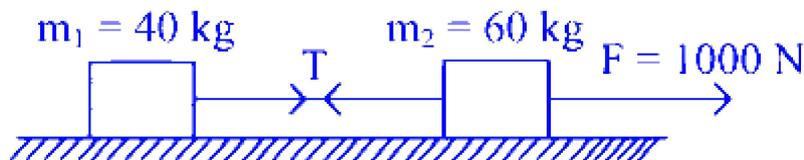
Options:

A. 450 N

B. 400 N

C. 350 N

D. 500 N

Answer: B

Solution:

The given situation is shown below

Let a be the common acceleration in the system of combination of blocks, then equation of motion of block m_1 is

$T = m_1 a$
$T = 40a$ .... (i)

and equation of motion of block m_2 is

$$F - T = m_2 a$$
$$\Rightarrow 1000 - T = m_2 a$$
$$\Rightarrow 1000 - T = 60 \times \left(\frac{T}{40}\right) \quad \text{[from Eq. (i)]}$$
$$\Rightarrow 1000 - T = \frac{3}{2}T \Rightarrow 2000 - 2T = 3T$$
$$\Rightarrow \quad T = \frac{2000}{5} = 400 \text{ N}$$

Question27

A 30 kg slab B rests on a frictionless floor asshown in the figure. A 10 kg block A rests ontop of the slab B. The coefficients of staticand kinetic friction between the block A andthe slab B are 0.60 and 0.40, respectively.When block A is acted upon by a horizontalforce of 100

N, as shown, find the resultingacceleration of the slab B. (g = 9.8 ms^2)

Image

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Options:

A. 0.98 ms^{-2}

B. 1.47 ms^{-2}

C. 1.52 ms^{-2}

D. 1.31 ms^{-2}

Answer: D

Solution:

Given, mass of bock $A, m_A = 10$ kg

Mass of slab $B, m_B = 30$ kg

Coefficient of static (μ_s) and kinetic friction, $(\mu_k) = 0.6$ and 0.4

Applied force, $F = 100$ N

Acceleration due to gravity, $g = 10$ ms^{-2}

According to given figure,

N_B is normal reaction on slab, $B = 40$ g

N_A is normal reaction on block, $A = 10$ g

Image

Static friction force $(f_s) = \mu_s N_A$

$= \frac{6}{10} \times 100 = 60$ N

Kinetic friction force $(f_k) = \mu_k N_A$

$= \frac{4}{10} \times 100 = 40$ N

$\because \quad F > f_s$

$\therefore$ There will be relative motionand force on slab $B, F_B = f_k = 40$ N

Acceleration of slab, $B = \frac{40}{30} = 1.33$ ms^{-2}

$\simeq 1.31$ ms^{-2}

Question28

A book is lying on a table. What is the anglebetween the normal reaction acting on thebook on the table and the weight of thebook?

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Options:

A. $0°$

B. $45°$

C. $90°$

D. $180°$
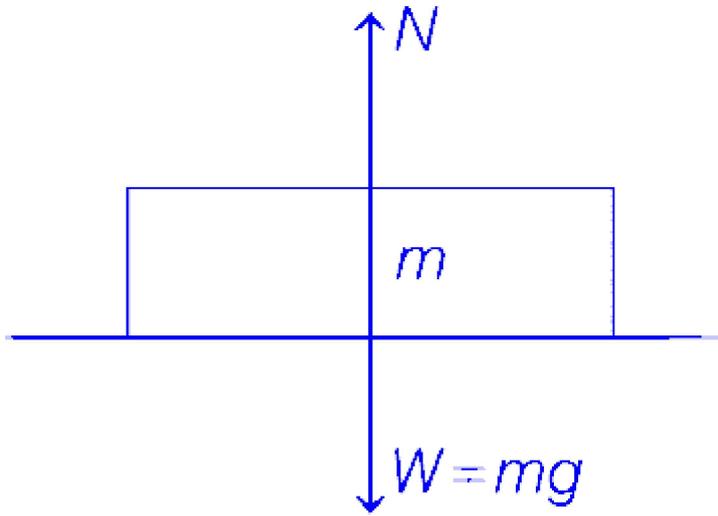
Answer: D

Solution:

As we know that,

W is weight of body and N be the normal reaction.

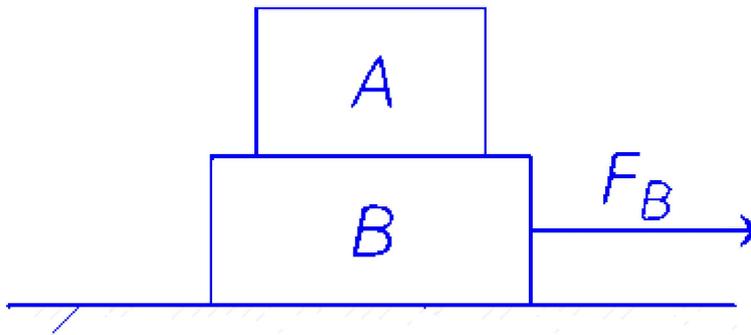Therefore, angle between W and N = 180Υ.

Question29

Two blocks A and B of masses 4 kg and 6 kg are as shown in the figure. A horizontal force of 12 N is required to make A slip over B. Find the maximum horizontal force F_B that can be applied on B, so that both A and B move together (take, $g = 10 \text{ ms}^{-2}$)

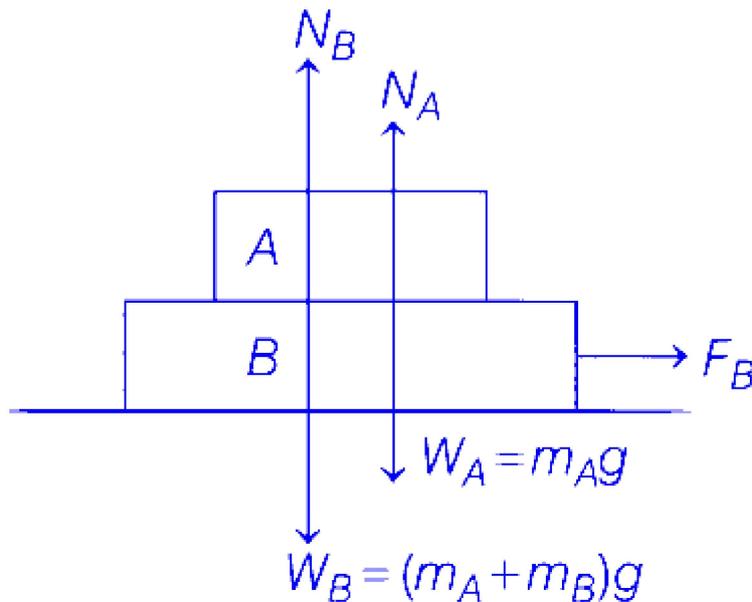**AP EAPCET 2021 - 19th August Evening Shift**

Options:

A. 30 N

B. 27 N

C. 32 N

D. 25 N

Answer: A

Solution:

Given, mass of block A and B are $m_A = 4$ kg and $m_B = 6$ kg

Friction between A and B, $f = 12$ N

Acceleration due to gravity, $g = 10 \text{ ms}^{-2}$

In order to move complete system together,

$F_B = (m_A + m_B)a$

$= (4 + 6)a$

$= 10a$ .... (i)

and $F_A = 12 = 4a \Rightarrow a = 3$

Substituting in Eq. (i), we get

$F_B = 10 \times 3 = 30$ N

Question30

An object dropped in a stationary lift takes time t_1 to reach the floor. It takes time t_2 when lift is moving up with constant acceleration. Then,

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Options:

A. $t_2 > t_1$

B. $t_1 > t_2$

C. $t_1 \approx t_2$

D. $t_1 = t_2$

Answer: B

Solution:

According to the question,

Time taken by ball to reach on floor when lift is stationary is t_1 and time taken by ball to reach on floor when lift is moving up with constant

Since, $s = ut + 1/2\, at^2$

Therefore, in case 2

$s = 0.t_1 + 1/2\, gt^2$ $[\because a = g]$

$\Rightarrow s = \frac{1}{2}gt_1^2$ ..... (i)

If a_{net} is net acceleration of ball, then in case 2 when lift is going up with acceleration a

$a_{\text{net}} = (g + a)$

$s = \frac{1}{2}(g+a)t_2^2$ .... (ii)

From Eqs. (i) and (ii), we get

$1/2gt_1^2 = 1/2(g+a)t_2^2$

$\therefore \quad t_1 > t_2$

Question31

When a body is placed on a rough plane (coefficient of friction $= \propto$) inclined at an angle θ to the horizontal, its acceleration is (acceleration due to gragvity $= g$)

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Options:

A. $g(\sin\theta - \propto \cos\theta)$

B. $g(\sin\theta - \cos\theta)$

C. $g \propto (\sin\theta - \cos\theta)$
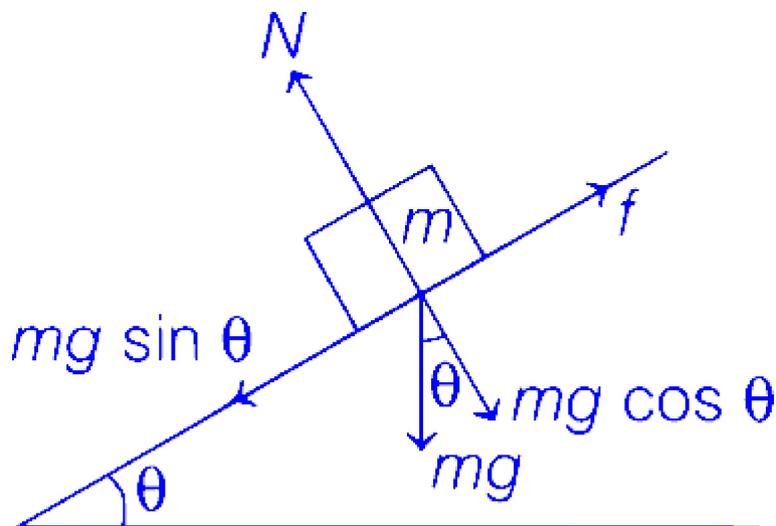
D. $g(\propto \sin\theta - \cos\theta)$

Answer: A

Solution:

Given, coefficient of friction $= \propto$

Angle of inclination $= \theta$

Acceleration due to gravity $= g$

Now, from the free body diagram of inclined plane and mass system.

Force along the plane, $mg\sin\theta - f = ma$

Here,

$f = \propto N$

$\Rightarrow \quad mg\sin\theta - \propto N = ma$ ..... (i)

and force along line perpendicular to plane will be

$N = mg\cos\theta$ ..... (ii)

where, m, f, a and N are mass, friction force, acceleration and normal reaction experienced by the body.

Now, from Eqs. (i) and (ii), we get

$$mg \sin \theta - \propto mg \cos \theta = ma$$
$$\Rightarrow \quad a = g(\sin \theta - \propto \cos \theta)$$