Laws Of Motion

Question1

A body of mass 1000kg is moving horizontally with a velocity 6m/ s. If 200kg extra mass is added, the final velocity (in m/ s) is:

[27-Jan-2024 Shift 1]

Options:

A.

6

B.

2

C.

3

D.

5

Answer: D

Solution:

Momentum will remain conserve

$1000 \times 6 = 1200 \times v$

$v = 5 m/s$

Question2

A train is moving with a speed of 12m/ s on rails which are 1.5m apart. To negotiate a curve radius 400m, the height by which the outer rail should be raised with respect to the inner rail is (Given, $g = 10 m/s^2$):

[27-Jan-2024 Shift 1]

Options:

A.

6.0 cm

B.

5.4 cm

C.

4.8 cm

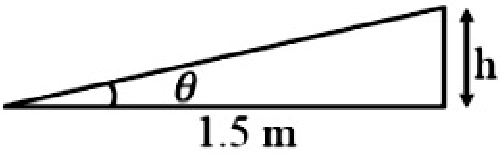
D.

4.2 cm

Answer: B

Solution:

$$\tan\theta = \frac{v^2}{Rg} = \frac{12\times 12}{10\times 400}$$



$$\tan\theta = \frac{h}{1.5}$$

$$\Rightarrow \frac{h}{1.5} = \frac{144}{4000}$$

$$h = 5.4\ \text{cm}$$

Question3

A heavy iron bar of weight 12kg is having its one end on the ground and the other on the shoulder of a man. The rod makes an angle 60° with the horizontal, the weight experienced by the man is :

[27-Jan-2024 Shift 2]

Options:

A.

6kg

B.

12kg

C.

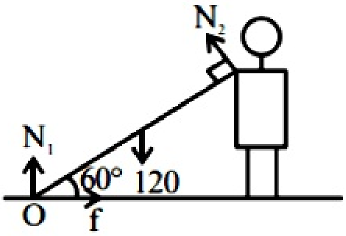
3kg

D.

6√3kg

Answer: C

Solution:



Torque about O = 0

$$120\left(\frac{L}{2}\cos 60^{\circ}\right) - N_2L = 0$$

$$N_2 = 30N$$

Question4

Given below are two statements :

Statement (I) : The limiting force of static friction depends on the area of contact and independent of materials.
Statement (II) : The limiting force of kinetic friction is independent of the area of contact and depends on materials.
In the light of the above statements, choose the most appropriate answer from the options given below :

[27-Jan-2024 Shift 2]

Options:

A.

Statement I is correct but Statement II is incorrect

B.

Statement I is incorrect but Statement II is correct

C.

Both Statement I and Statement II are incorrect

D.

Both Statement I and Statement II are correct

Answer: B

Solution:

Co-efficient of friction depends on surface in contact So, depends on material of object.

Question5

A stone of mass 900g is tied to a string and moved in a vertical circle of radius 1m making 10rpm. The tension in the string, when the stone is at the lowest point is (if $\pi^2 = 9.8$ and $g = 9.8 m/s^2$)

[29-Jan-2024 Shift 2]

Options:

A.

97N

B.

9.8N

C.

8.82N

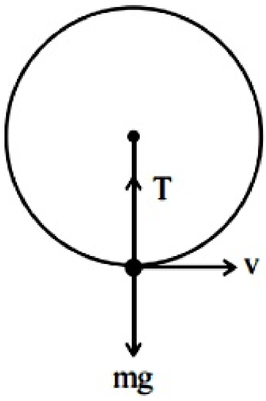
D.

17.8N

Answer: B

Solution:

Given that



$m = 900 \text{ gm} = \frac{900}{1000} \text{kg} = \frac{9}{10} \text{kg}$

$r = 1m$

$\omega = \frac{2\pi N}{60} = \frac{2\pi(10)}{60} = \frac{\pi}{3} \text{rad}/ sec$

$T - mg = mr\omega^2$

$T = mg + mr\omega^2$

$= \frac{9}{10} \times 9.8 + \frac{9}{10} \times 1\left(\frac{\pi}{3}\right)^2$

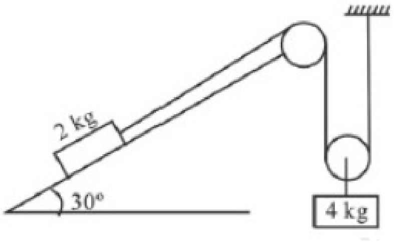
$= 8.82 + \frac{9}{10} \times \frac{\pi^2}{9}$

$= 8.82 + 0.98$

$= 9.80N$

Question6

All surfaces shown in figure are assumed to be frictionless and the pulleys and the string are light. The acceleration of the block of mass 2kg is :



[30-Jan-2024 Shift 1]

Options:

A.

g

B.

g/3

C.

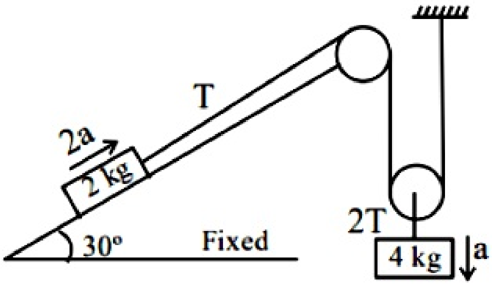
g/2

D.

g/4

Answer: B

Solution:



$40 - 2T = 4a$

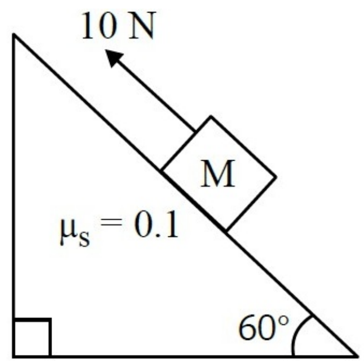
$T - 10 = 4a \Rightarrow 20 = 12a$

$\Rightarrow a = 5/3 \Rightarrow 2a = \frac{g}{3}$

Question7

A block of mass 1kg is pushed up a surface inclined to horizontal at an angle of 60∘ by a force of 10N parallel to the inclined surface as shown

in figure. When the block is pushed up by 10m along inclined surface, the work done against frictional force is : [g = 10m/ s^2]



[30-Jan-2024 Shift 2]

Options:

A.

$5\sqrt{3}$J

B.

5J

C.

5×10^3J

D.

10J

Answer: B

Solution:

Work done again frictional force

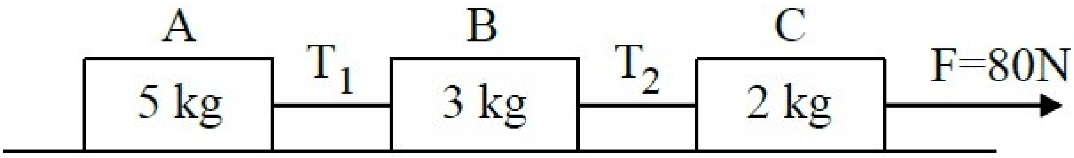
$= \mu N \times 10$

$= 0.1 \times 5 \times 10 = 5J$

Question8

Three blocks A, B and C are pulled on a horizontal smooth surface by a force of 80N as shown in figure

The tensions T_1 and T_2 in the string are respectively:



[30-Jan-2024 Shift 2]

Options:

A.

40N, 64N

B.

60N, 80N

C.

88N, 96N

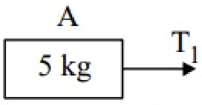
D.

80N, 100N

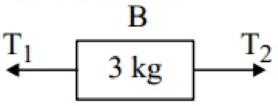
Answer: A

Solution:

$$a_A = a_B = a_C = \frac{F}{5+3+2} = \frac{80}{10} = 8m/s^2$$



$T_1 = 5 \times 8 = 40$



$T_2 - T_1 = 3 \times 8 \Rightarrow T_2 = 64$

B.

1/2m

C.

1/6m

D.

1/3m

Answer: A

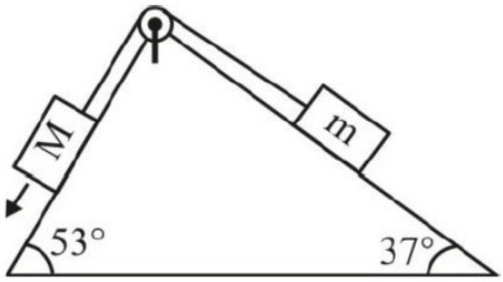
Solution:

$$\frac{dy}{dx} = \tan\theta = \frac{x}{2} = \mu = \frac{1}{2}$$

$x = 1, y = 1/4$

Question10

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 $\tan 37^\circ = 3/4$)



[31-Jan-2024 Shift 1]

Options:

A.

9 kg

B.

4.5 kg

C.

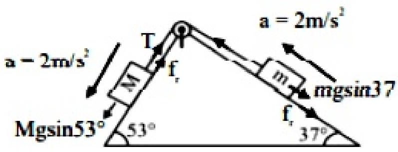
6.5 kg

D.

2.25 kg

Answer: B

Solution:



For M block

$10g\sin 53^\circ - \mu(10g)\cos 53^\circ - T = 10 \times 2$

$T = 80 - 15 - 20$

$T = 45N$

For m block

$T - mg\sin 37^\circ - \mu mg\cos 37^\circ = m \times 2$

$45 = 10m$

$m = 4.5\,kg$

Question11

A coin is placed on a disc. The coefficient of friction between the coin and the disc is μ. If the distance of the coin from the center of the disc is r, the maximum angular velocity which can be given to the disc, so that the coin does not slip away, is :

[31-Jan-2024 Shift 1]

Options:

A.

μg/r

B.

$\sqrt{\frac{r}{\mu g}}$

C.

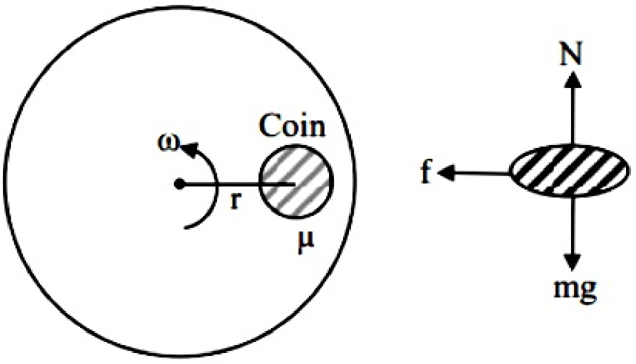
$\sqrt{\frac{\mu g}{r}}$

D.

$\frac{\mu}{\sqrt{rg}}$

Answer: C

Solution:



$N = mg$

$f = m\omega^2 r$

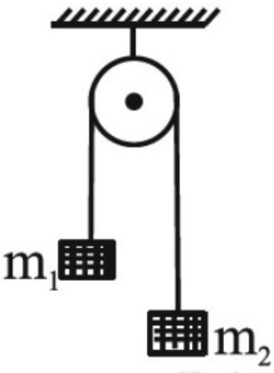
$f = \mu N$

$\mu mg = mr\omega^2$

$\omega = \sqrt{\frac{\mu g}{r}}$

Question12

A light string passing over a smooth light fixed pulley connects two blocks of masses m1 and m2. If the acceleration of the system is g/8, then the ratio of masses is



[31-Jan-2024 Shift 2]

Options:

A.

9/7

B.

8/1

C.

4/3

D.

5/3

Answer: A

Solution:

$$a = \frac{(m_1 - m_2)g}{(m_1 + m_2)} = \frac{g}{8}$$

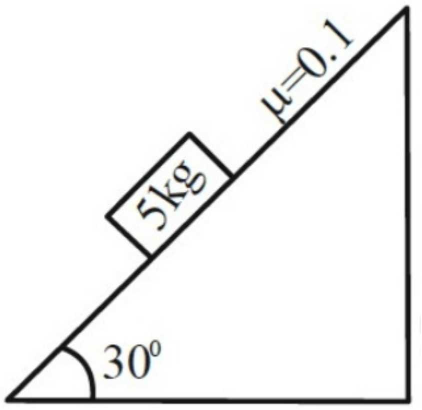
$$8m_1 - 8m_2 = m_1 + m_2$$

$$7m_1 = 9m_2$$

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

Question13

A block of mass 5kg 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=10m/ s^2]

[31-Jan-2024 Shift 2]

Options:

A.

25√3N

B.

5√3N

C.

$\frac{5\sqrt{3}}{2}N$

D.

10N

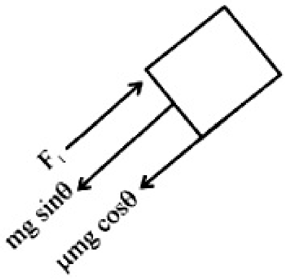
Answer: B

Solution:

$f_K = \mu mg\cos\theta$

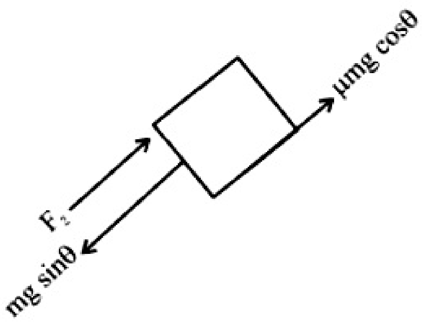
$= 0.1 \times \frac{50 \times \sqrt{3}}{2}$

$= 2.5\sqrt{3}N$



$F_1 = mg\sin\theta + f_K$

$= 25 + 2.5\sqrt{3}$



$F_2 = mg\sin\theta - f_K$

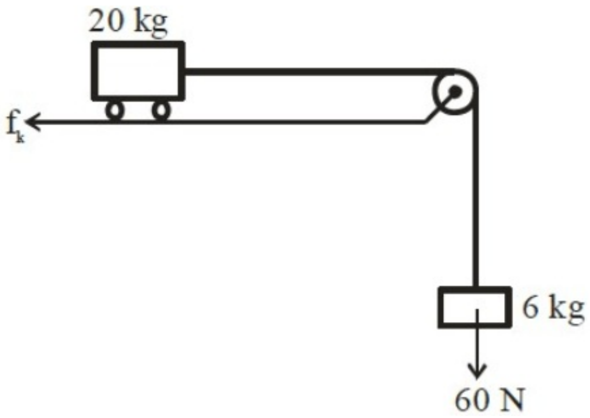
$= 25 - 2.5\sqrt{3}$

$\therefore F_1 - F_2 = 5\sqrt{3}N$

Question14

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) :



[1-Feb-2024 Shift 1]

Options:

A.

3

B.

4

C.

2

D.

1.2

Answer: C

Solution:

$f_k = \mu N = 0.04 \times 20g = 8$ Newton

$a = \frac{60 - 8}{26} = 2m/s^2$

Question15

A body of mass 4 kg experiences two forces $\vec{F}_1 = 5\hat{i} + 8\hat{j} + 7\hat{k}$ and $\vec{F}_2 = 3\hat{i} - 4\hat{j} - 3\hat{k}$. **The acceleration acting on the body is :**

[1-Feb-2024 Shift 2]

Options:

A.

$-2\hat{i} - \hat{j} - \hat{k}$

B.

$4\hat{i}+2\hat{j}+2\hat{k}$

C.

$2\hat{i}+\hat{j}+\hat{k}$

D.

$2\hat{i}+3\hat{j}+3\hat{k}$

Answer: C

Solution:

$$\text{Net force } = 8\hat{i}+4\hat{j}+4\hat{k}$$

$$\vec{a} = \frac{\vec{F}}{m} = 2\hat{i}+\hat{j}+\hat{k}$$

Question16

A cricket player catches a ball of mass 120g moving with 25m/ s speed. If the catching process is completed in 0.1 s then the magnitude of force exerted by the ball on the hand of player will be (in SI unit):

[1-Feb-2024 Shift 2]

Options:

A.

24

B.

12

C.

25

D.

30

Answer: D

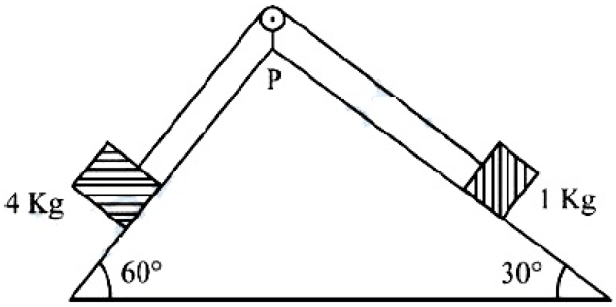
Solution:

$$F_{av} = \frac{\Delta p}{\Delta t}$$

$$= \frac{0.12 \times 25}{0.1} = 30N$$

Question17

As per given figure, a weightless pulley P is attached on a double inclined frictionless surface. The tension in the string (massless) will be (if $g = 10m/s^2$)



[24-Jan-2023 Shift 1]

Options:

A. $(4\sqrt{3}+1)N$

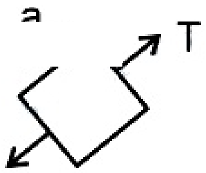
B. $4(\sqrt{3}+1)N$

C. $4(\sqrt{3}-1)N$

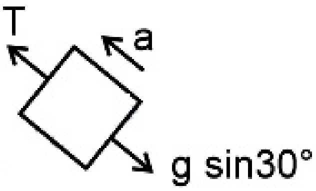
D. $(4\sqrt{3}-1)N$

Answer: B

Solution:



$4g\sin 60^\circ - T = 4a \ldots (1)$
$4g\sin 60^\circ$



$T - g\sin 30^\circ = a \ldots (2)$
Solving (1) and (2) we get.
$20\sqrt{3} - T = 4T - 20$
$T = 4(\sqrt{3}+1)N$

Question18

Given below are two statements :
Statement-I : An elevator can go up or down with uniform speed when

its weight is balanced with the tension of its cable.
Statement-II : Force exerted by the floor of an elevator on the foot of a person standing on it is more than his/her weight when the elevator goes down with increasing speed.
In the light of the above statements, choose the correct answer from the options given below :
[24-Jan-2023 Shift 1]

Options:

A. Both statement I and statement II are false

B. Statement I is true but Statement II is false

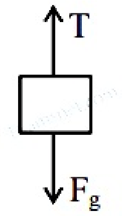
C. Both Statement I and Statement II are true

D. Statement I is false but Statement II is true

Answer: B

Solution:

Solution:
Statement-1
When elevator is moving with uniform speed $T = F_g$
Statement-2



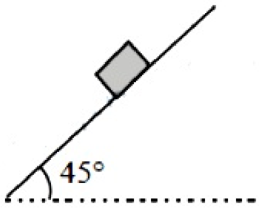
When elevator is going down with increasing speed, its acceleration is downward.
Hence

$W - N = \frac{W}{g} \times a$

$N = W\left(1 - \frac{a}{g}\right)$ i.e. less than weight.

Question19

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-Jan-2023 Shift 2]

Options:

A. 0.33

B. 0.60

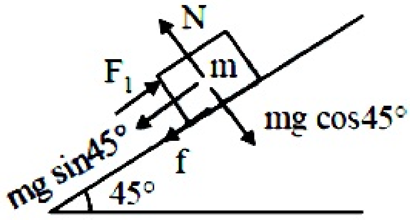
C. 0.25

D. 0.50

Answer: A

Solution:

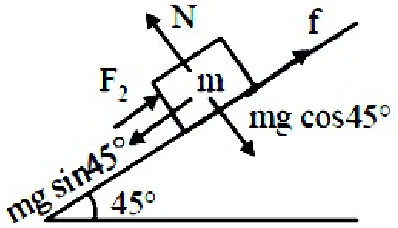
Solution:



$F_1 = mg\sin 45^\circ + f = mg\sin 45^\circ + \mu N$

$F_1 = \frac{mg}{\sqrt{2}} + \mu\, mg\cos 45^\circ$

$F_1 = \frac{mg}{\sqrt{2}}(1 + \mu)$



$F_2 = mg\sin 45^\circ - f = mg\sin 45^\circ - \mu N$

$= \frac{mg}{\sqrt{2}}(1 - \mu)$

$F_1 = 2F_2$

$\frac{mg}{\sqrt{2}}(1 + \mu) = 2\,\frac{mg}{\sqrt{2}}(1 - \mu)$

$1 + \mu = 2 - 2\mu$

$\mu = 1/3 = 0.33$

Question20

A block of mass m slides down the plane inclined at angle 30° with an acceleration $\frac{g}{4}$. The value of coefficient of kinetic friction will be : [29-Jan-2023 Shift 1]

Options:

A. $\frac{2\sqrt{3}+1}{2}$

B. $\frac{1}{2\sqrt{3}}$

C. $\frac{\sqrt{3}}{2}$

D. $\frac{2\sqrt{3}-1}{2}$

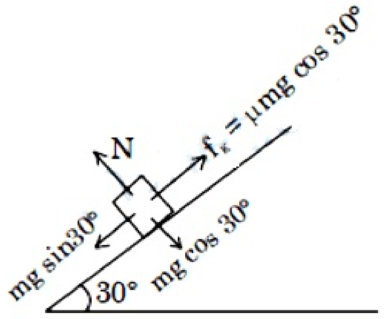
Answer: B

Solution:

Solution:

$Mg\sin 30^\circ - \mu mg\cos 30^\circ = ma$

$\frac{g}{2} - \frac{\sqrt{3}}{2} \cdot \mu g = \frac{g}{4}$



$\frac{\sqrt{3}}{2}\mu = \frac{1}{4}$

$\mu = \frac{1}{2\sqrt{3}}$

Question21

Force acts for 20 s on a body of mass 20 kg, starting from rest, after which the force ceases and then body describes 50m in the next 10 s. The value of force will be :
[29-Jan-2023 Shift 2]

Options:

A. 40N

B. 5N

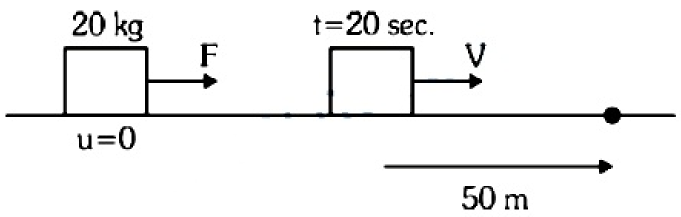
C. 20N

D. 10N

Answer: B

Solution:

Solution:



$50 = V \times 10$
$V = 5m / s$
$V = 0 + a \times 20$
$5 = a \times 20$
$a = \frac{1}{4} m / s^2$
$F = ma = 20 \times \frac{1}{4} = 5N$

Question22

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-Jan-2023 Shift 2]

Options:

A. $\sqrt{\frac{1}{1-n^2}}$

B. $\sqrt{1-\frac{1}{n^2}}$

C. $1+\frac{1}{n^2}$

D. $1-\frac{1}{n^2}$

Answer: D

Solution:

Solution:

$a_1 = g\sin\theta = g/\sqrt{2}$

$a_2 = g\sin\theta - Kg\cos\theta = \frac{g}{\sqrt{2}} - \frac{Kg}{\sqrt{2}}$

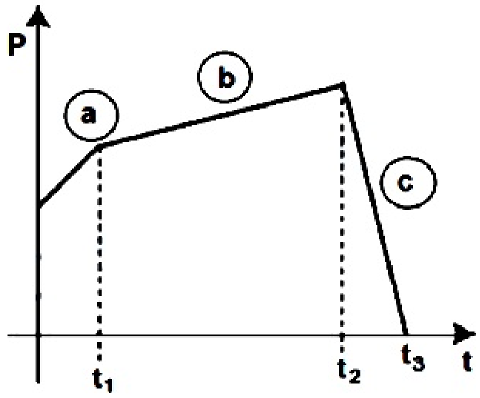
$t_2 = nt_1 \;\&\; a_1t_1^{\,2} = a_2t_2^{\,2}$

$\frac{g}{\sqrt{2}}t_1^{\,2} = \left(\frac{g}{\sqrt{2}} - \frac{kg}{\sqrt{2}}\right)n^2t_1^{\,2}$

$K = 1 - \frac{1}{n^2}$ Ans. 4

Question23

The figure represents the momentum time $(p-t)$ curve for a particle moving along an axis under the influence of the force. Identify the regions on the graph where the magnitude of the force is maximum and minimum respectively ?
If $(t_3 - t_2) < t_1$.



[30-Jan-2023 Shift 1]

Options:

A. c and a

B. b and c

C. c and b

D. a and b

Answer: C

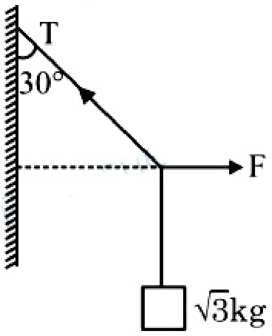
Solution:

Solution:

$\left| d\frac{\vec{p}}{dt} \right| = \left| \vec{F} \right| \Rightarrow d\frac{\vec{p}}{dt} =$ Slope of curve
max slope (c)
min slope (b)

Question24

A block of $\sqrt{3}$ kg is attached to a string whose other end is attached to the wall. An unknown force F is applied so that the string makes an angle of 30° with the wall. The tension T is :
(. Given g = $10 ms^{-2}$)



[30-Jan-2023 Shift 2]

Options:

A. 20N

B. 25N

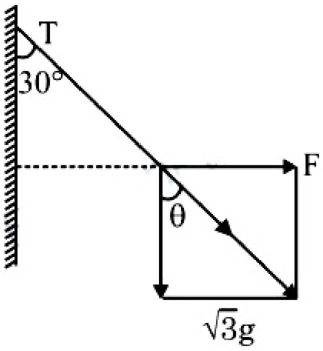
C. 10N

D. 15N

Answer: A

Solution:

Solution:



$\theta = 30^\circ$

$\cos\theta = \frac{\sqrt{3}g}{T}$

$\Rightarrow \frac{\sqrt{3}}{2} = \frac{\sqrt{3}g}{T}$

$\Rightarrow T = 20N$

Question25

A stone tied to 180 cm long string at its end is making 28 revolutions in horizontal circle in every minute. The magnitude of acceleration of stone is $\frac{1936}{x}ms^{-2}$. The value of x ________.

$\left(\text{Take } \pi = \frac{22}{7} \right)$

[30-Jan-2023 Shift 2]

Solution:

$a = \omega^2 R = \left(\frac{28 \times 2\pi}{60} \right)^2 \times 1.8$

$= \left(\frac{56}{60} \times \frac{22}{7} \right)^2 \times 1.8$

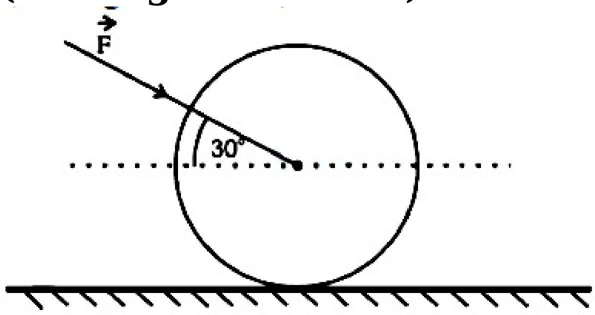
$= \frac{(44)^2}{225} \times 1.8$

$= \frac{1936 \times 1.8}{225}$

$x = 125$

Question26

As shown in figure, a 70 kg garden roller is pushed with a force of $\vec{F} = 200N$ at an angle of 30° with horizontal. The normal reaction on the roller is
(Given $g = 10 m\ s^{-2}$)



[31-Jan-2023 Shift 1]

Options:

A. $800\sqrt{2}N$

B. 600N

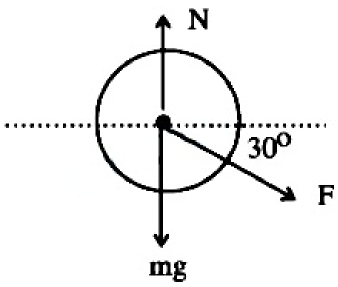
C. 800N

D. $200\sqrt{3}N$

Answer: C

Solution:

Solution:
$N = mg + F\sin 30^\circ$
$= 700 + 200 \times \frac{1}{2} = 800$ newton.



Question27

A lift of mass M = 500 kg is descending with speed of $2ms^{-1}$. Its supporting cable begins to slip thus allowing it to fall with a constant acceleration of $2ms^{-2}$. The kinetic energy of the lift at the end of fall through to a distance of 6m will be _______ kJ.
[31-Jan-2023 Shift 1]

Answer: 7

Solution:

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

$= 4 + 24 = 28$

$KE = \frac{1}{2}mv^2$

$= \frac{1}{2}(500)28$

$= 7000J$

$= 7\,kJ$

Ans. 7

Question28

A stone of mass 1 kg is tied to end of a massless string of length 1m. If the breaking tension of the string is 400N, then maximum linear velocity, the stone can have without breaking the string, while rotating in horizontal plane, is:
[31-Jan-2023 Shift 2]

Options:

A. $20ms^{-1}$

B. $40ms^{-1}$

C. $400ms^{-1}$

D. $10ms^{-1}$

Answer: A

Solution:

$T\sin\theta = \frac{mv^2}{l\sin\theta}$
$\cos\theta = \frac{mg}{T}$........ (i)
$\sin^2\theta = \frac{mv^2}{Tl}$........ (ii)
From (i) and (ii),
$1 = \left(\frac{mg}{T}\right)^2 + \frac{mv^2}{Tl}$
$\Rightarrow 1 = \left(\frac{10}{400}\right)^2 + \frac{v^2}{400}$
$\Rightarrow v^2 = 399.78$
$\Rightarrow v = 20m/s$

Question29

A body of mass 10 kg is moving with an initial speed of 20m / s. The body stops after 5 s due to friction between body and the floor. The value of the coefficient of friction is: (Take acceleration due to gravity $g = 10ms^{-2}$)
[31-Jan-2023 Shift 2]

Options:

A. 0.2

B. 0.3

C. 0.5

D. 0.4

Answer: D

Solution:

$a = -\mu g$
$\because v = u + at$
$0 = 20 + (-\mu \times 10) \times 5$
$50\mu = 20$
$\mu = \frac{2}{5} = 0.4$

Question30

A block of mass 5 kg is placed at rest on a table of rough surface. Now, if a force of 30N is applied in the direction parallel to surface of the table, the block slides through a distance of 50m in an interval of time 10 s. Coefficient of kinetic friction is (given, $g = 10ms^{-2}$):
[1-Feb-2023 Shift 1]

Options:

A. 0.60

B. 0.75

C. 0.50

D. 0.25

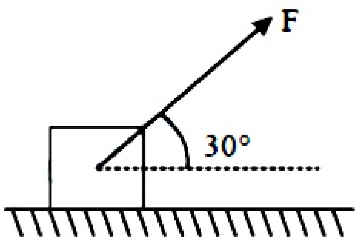
Answer: C

Solution:

$$50 = 0 + \frac{1}{2} \times a \times 100$$
$$a = 1 m / s^2$$
$$F - \mu mg = ma$$
$$30 - \mu \times 50 = 5 \times 1$$
$$50\mu = 25$$
$$\mu = \frac{1}{2}$$

Question31

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 $\mu_5 = 0.25$, the block will just start to move for the value of F : [Given $g = 10ms^{-2}$]



[1-Feb-2023 Shift 2]

Options:

A. 33.3N

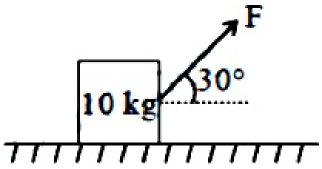
B. 25.2N

C. 20N

D. 35.7N

Answer: B

Solution:



$N = Mg - F \sin 30^{\circ}$

$= mg - \frac{F}{2} = 100 - \frac{F}{2} = \frac{200 - F}{2}$

$F \cos 30^{\circ} = \mu N$

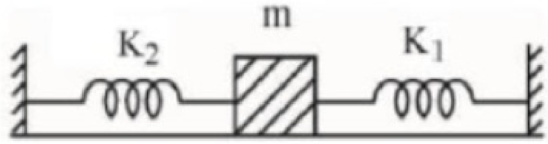
$\sqrt{3}\frac{F}{2} = 0.25 \times \left(\frac{200 - F}{2}\right)$

$4\sqrt{3}F = 200 - F$

$F = \frac{200}{4\sqrt{3} + 1} = 25.22$

Question32

A mass m is attached to two strings as shown in figure. The spring constants of two springs are K_1 and K_2. For the frictionless surface, the time period of oscillation of mass m is



[6-Apr-2023 shift 1]

Options:

A. $2\pi\sqrt{\frac{m}{K_1 - K_2}}$

B. $\frac{1}{2\pi}\sqrt{\frac{K_1 - K_2}{m}}$

C. $\frac{1}{2\pi}\sqrt{\frac{K_1 + K_2}{m}}$

D. $2\pi\sqrt{\frac{m}{K_1 + K_2}}$

Answer: D

Solution:

Solution:
Both the springs are in parallel.

$K_{eq} = K_1 + K_2$

$T = 2\pi\sqrt{\frac{m}{K_{eq}}} = 2\pi\sqrt{\frac{m}{K_1 + K_2}}$

Question33

A small block of mass 100g is tied to a spring of spring constant

7.5N / m and length 20 cm. The other end of spring is fixed at a particular point A. If the block moves in a circular path on a smooth horizontal surface with constant angular velocity 5 rad / s about point A, then tension in the spring is -
[6-Apr-2023 shift 1]

Options:

A. 0.75N

B. 1.5N

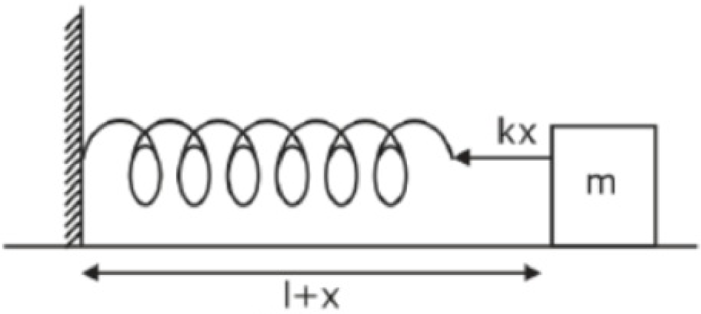
C. 0.25N

D. 0.50N

Answer: A

Solution:

Solution:



$kx = m\omega^2 r$
$\Rightarrow kx = 0.1 \times 25 \times (0.2 + x)$
$\Rightarrow 7.5x = 2.5(0.2 + x)$
$\Rightarrow 3x = 0.2 + x$
$\Rightarrow 2x = 0.2$
$\Rightarrow x = 0.1m$
Now, tension in the spring $= kx = 7.5 \times 0.1N = 0.75N$

Question34

At any instant the velocity of a particle of mass 500g is $\left(2t\hat{i} + 3t^2\hat{j}\right) ms^{-1}$. If the force acting on the particle at t = 1 s is $\left(\hat{i} + x\hat{j}\right)$N. Then the value of x will be:
[8-Apr-2023 shift 1]

Options:

A. 2

B. 6

C. 3

D. 4

Answer: C

Solution:

Solution:

$\vec{V} = \left(2t\hat{i} + 3t^2\hat{j}\right) m / s, \quad \text{mass } m = 500\,gm$

Force, $\vec{F} = ma$ -

$\vec{F} = \frac{1}{2}\left(\frac{d\vec{v}}{dt}\right) \Rightarrow \vec{F} = \frac{1}{2}\left(2\hat{i} + 6\hat{t}\right)$

$\vec{F} = \left(\hat{i} + 3\hat{t}\right)$

At $t = 1\,s \Rightarrow \vec{F} = \left(\hat{i} + 3\hat{j}\right)$

$x = 3$

Question35

Given below are two statements : one is labelled as Assertion A and then 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-Apr-2023 shift 2]

Options:

A. A is not correct but R is correct

B. Both A and R are correct and R is the correct explanation of A

C. Both A and R are correct but R is NOT the correct explanation of A

D. A is correct but R is not correct

Answer: B

Solution:

Solution:
Inertia is the property of mass due to which the object continues to move until any external force do not stops it. In the case of rotation of fan, if we switch off then also it moves for some time as air resistance takes time to stop it and due to inertia of fan it moves for some time.

Question36

A coin placed on a rotating table just slips when it is placed at a distance of 1 cm from the center. If the angular velocity of the table in halved, it will just slip when placed at a distance of _______ from the centre :
[11-Apr-2023 shift 1]

Options:

A. 8 cm

B. 4 cm

C. 2 cm

D. 1 cm

Answer: B

Solution:

Solution:

$f r = m\omega^2 r$

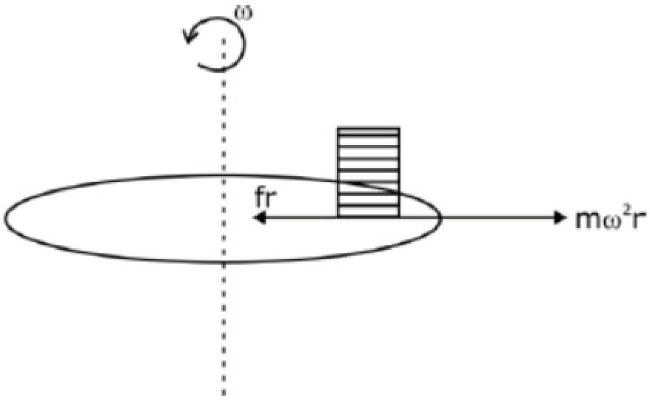
$\mu mg = m\omega^2 r = \text{const}$

$\omega^2 r = \text{const}$

$\omega_1^2 r_1 = \omega_2^2 r_2$

$\omega^2(1) = \left(\frac{\omega}{2}\right)^2 r_2$

$r_2 = 4\text{ cm}$



Question37

A body of mass 500g moves along x-axis such that it's velocity varies with displacement x according to the relation $v = 10\sqrt{x}$ m / s the force acting on the body is:-
[11-Apr-2023 shift 2]

Options:

A. 25N

B. 5N

C. 166N

D. 125N

Answer: A

Solution:

Solution:

$v = 10\sqrt{x} \Rightarrow \frac{dv}{dx} = \frac{10}{2\sqrt{x}} = \frac{5}{\sqrt{x}}$

$a = v\frac{dv}{dx}$

$a = v \times \frac{5}{\sqrt{x}} = 10\sqrt{x} \times \frac{5}{\sqrt{x}} = 50ms^{-2}$

$F = ma = \frac{500}{1000} \times 50 = 25N$

Question38

The position vector of a particle related to time t is given by
$\vec{r} = \left(10t\hat{i} + 15t^2\hat{j} + 7\hat{k}\right)m$
The direction of net force experienced by the particle is :
[15-Apr-2023 shift 1]

Options:

A. Positive z-axis

B. In $x - y$ plane

C. Positive y-axis

D. Positive x-axis

Answer: C

Solution:

Solution:

Given, $\vec{r} = 10t\hat{i} + 15t^2\hat{j} + 7\hat{k}$

$\vec{v} = \frac{d\vec{r}}{dt} = 10\hat{j} + 30\hat{j}$

$\vec{a} = \frac{d\vec{v}}{dt} = 30\hat{j}$

$\vec{F} = m\vec{a} \rightarrow$ along (+)y -axis

Question39

A uniform chain of 6m 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.
[25-Jun-2022-Shift-1]

Answer: 2

Solution:

Solution:
$(x)g\lambda = \mu(6 - x)g\lambda$ where x is length of hanging part
$\Rightarrow x = 3 - 0.5x$
$\Rightarrow x = 2m$

Question40

A force on an object of mass 100g is $\left(10\hat{i} + 5\hat{j}\right)$N. The position of that object at t = 2s is $\left(a\hat{i} + b\hat{j}\right)$m after starting from rest. The value of $\frac{a}{b}$ will be_____
[25-Jun-2022-Shift-1]

Answer: 2

Solution:

Solution:
$\vec{F} = m\vec{a}$
$\Rightarrow \vec{a} = 100\hat{i} + 50\hat{j}$
So, $\vec{S} = \frac{1}{2}\vec{a}t^2$
$\frac{1}{2}\left(100\hat{i} + 50\hat{j}\right)2^2$
$= 200\hat{i} + 100\hat{j}m$
so a $= 200m$ and $b = 100m$
so $\frac{a}{b} = 2$

Question41

A disc with a flat small bottom beaker placed on it at a distance R from its center is revolving about an axis passing through the center and perpendicular to its plane with an angular velocity ω. The coefficient of static friction between the bottom of the beaker and the surface of the disc is μ. The beaker will revolve with the disc if :
[25-Jun-2022-Shift-2]

Options:

A. $R \le \frac{\mu g}{2\omega^2}$

B. $R \le \frac{\mu g}{\omega^2}$

C. $R \ge \frac{\mu g}{2\omega^2}$

D. $R \geq \frac{\mu g}{\omega^2}$

Answer: B

Solution:

Solution:
To move together
$\omega^2 R \leq \mu g$
$\Rightarrow R \leq \frac{\mu g}{\omega^2}$

Question42

A curved in a level road has a radius 75m. The maximum speed of a car turning this curved road can be 30m / s without skidding. If radius of curved road is changed to 48m and the coefficient of friction between the tyres and the road remains same, then maximum allowed speed would be ____m / s
[25-Jun-2022-Shift-2]

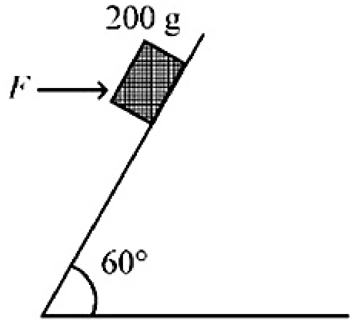
Answer: 24

Solution:

Solution:
$\because v = \sqrt{\mu g r}$
$\Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{r_1}{r_2}}$
$\Rightarrow \frac{30}{v_2} = \sqrt{\frac{75}{48}} = \sqrt{\frac{25}{16}} = \frac{5}{4}$
$\Rightarrow V_2 = 24 m / s$

Question43

A block of mass 200g is kept stationary on a smooth inclined plane by applying a minimum horizontal force F = $\sqrt{x}$N as shown in figure.

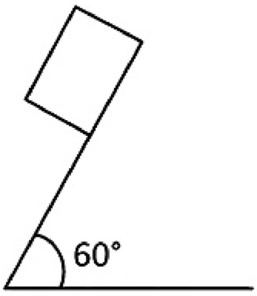


The value of x =
[25-Jun-2022-Shift-2]

Answer: 12

Solution:

Solution:



F cos60° = mg sin60°

$F \times \frac{1}{2} = 0.2 \times 10 \times \frac{\sqrt{3}}{2}$

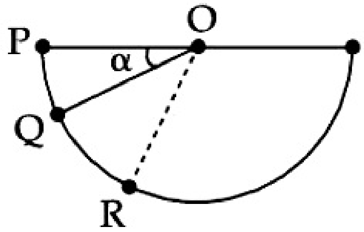
$\Rightarrow F = 2\sqrt{3}$

$\Rightarrow F = \sqrt{12} N$

$\therefore x = 12$

Question44

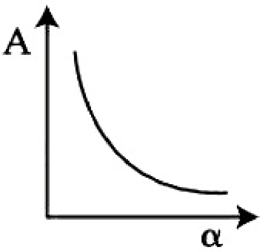
A ball is released from rest from point P of a smooth semi-spherical vessel as shown in figure. The ratio of the centripetal force and normal reaction on the ball at point Q is A while angular position of point Q is α with respect to point P. Which of the following graphs represent the correct relation between A and α when ball goes from Q to R ?



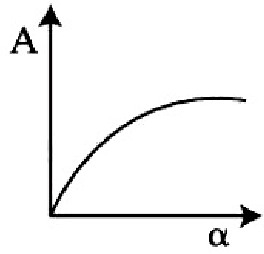
[26-Jun-2022-Shift-1]

Options:

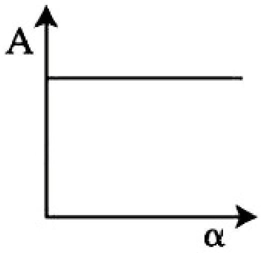
A.



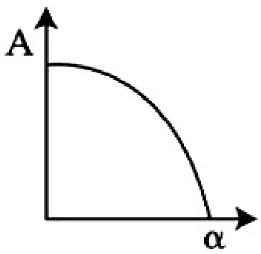
B.



C.



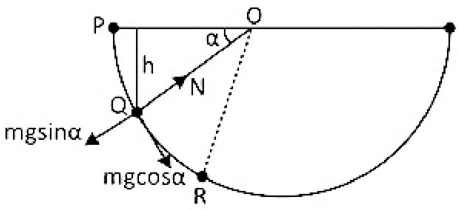
D.



Answer: C

Solution:

Solution:



$h = R\sin\alpha$

$v = \sqrt{2gh} = \sqrt{2gR\sin\alpha}$

$a_c = \frac{v^2}{R} = \frac{2gR\sin\alpha}{R} = 2g\sin\alpha$

Now, at Q;

$N - mg\sin\alpha = ma_c$

$N = m \times 2g\sin\alpha + mg\sin\alpha$

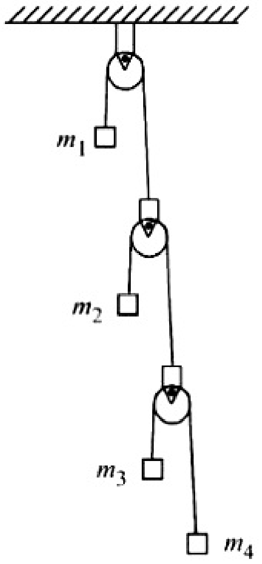
$= 3mg\sin\alpha$

$\frac{M\,a_c}{N} = \frac{2mg\sin\alpha}{3mg\sin\alpha} = \frac{2}{3} = \text{constant}$

Question45

In the arrangement shown in figure a_1, a_2, a_3 and a_4 are the accelerations of masses m_1, m_2, m_3 and m_4 respectively. Which of the

following relation is true for this arrangement?



[26-Jun-2022-Shift-2]

Options:

A. $4a_1 + 2a_2 + a_3 + a_4 = 0$

B. $a_1 + 4a_2 + 3a_3 + a_4 = 0$

C. $a_1 + 4a_2 + 3a_3 + 2a_4 = 0$

D. $2a_1 + 2a_2 + 3a_3 + a_4 = 0$

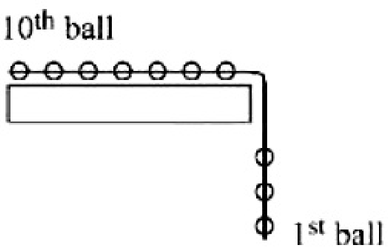
Answer: A

Solution:

Solution:
From virtual work done method,
$4T \times a_1 + 2T \times a_2 + T \times a_3 + T \times a_4 = 0$
$\Rightarrow 4a_1 + 2a_2 + a_3 + a_4 = 0$

Question46

A system to 10 balls each of mass 2 kg are connected via massless and unstretchable 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.



[26-Jun-2022-Shift-2]

Answer: 36

Solution:

Solution:
At given instant

$a_{sys} = \frac{6m \times g}{10m} = \frac{6g}{10}$

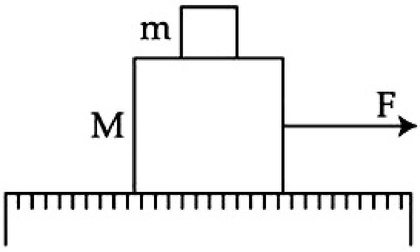
$\therefore T_{78} = (3m) \times a_{sys}$

$= (3m) \times \left(\frac{6g}{10}\right)$

$= \frac{3 \times 2 \times 6 \times 10}{10} = 36N$

Question47

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 :



[27-Jun-2022-Shift-1]

Options:

A. 9.8N

B. 39.2N

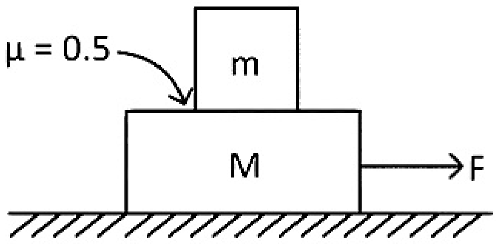
C. 49N

D. 78.4N

Answer: C

Solution:

Solution:



$\therefore a_{max} = \mu g$

$= 0.5 \times 9.8 = 4.9 m / s^2$

$\therefore F_{max} = (8 + 2) \times 4.9 = 49N$

Question48

One end of a massless spring of spring constant k and natural length I_0 is fixed while the other end is connected to a small object of mass m lying on a frictionless table. The spring remains horizontal on the table. If the object is made to rotate at an angular velocity ω about an axis passing through fixed end, then the elongation of the spring will be : [27-Jun-2022-Shift-2]

Options:

A. $\frac{k - m\omega^2 l_0}{m\omega^2}$

B. $\frac{m\omega^2 l_0}{k + m\omega^2}$

C. $\frac{m\omega^2 l_0}{k - m\omega^2}$

D. $\frac{k + m\omega^2 l_0}{m\omega^2}$

Answer: C

Solution:

Solution:

$m\omega^2(l_0 + x) = kx$

$\Rightarrow m\omega^2 l_0 = (k - m\omega^2) \times x$

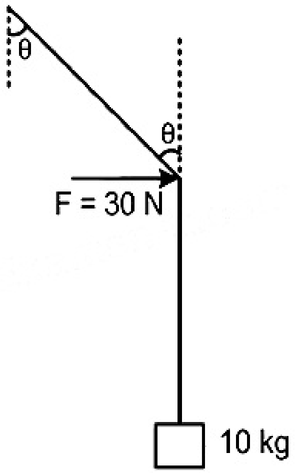
$\Rightarrow x = \frac{m\omega^2 l_0}{(k - m\omega^2)}$

Question49

A mass of 10 kg is suspended vertically by a rope of length 5m from the roof. A force of 30N is applied at the middle point of rope in horizontal direction. The angle made by upper half of the rope with vertical is $\theta = \tan^{-1}(x \times 10^{-1})$. The value of x is____(Given, $g = 10m / s^2$) [27-Jun-2022-Shift-2]

Answer: 3

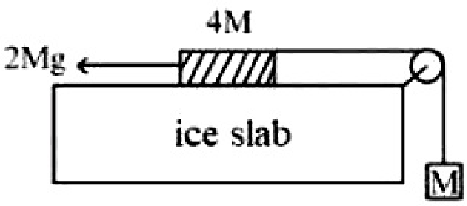
Solution:



$T\cos\theta = mg$
$T\cos\theta = 100N$
$T\sin\theta = 30$
$\Rightarrow \frac{T\sin\theta}{T\cos\theta} = \frac{30}{100}$
$\Rightarrow \tan\theta = \frac{3}{10}$
$\therefore x = 3$

Question50

A hanging mass M is connected to a four times bigger mass by using a string-pulley arrangement, as shown in the figure. The bigger mass is placed on a horizontal ice-slab and being pulled by 2 Mg force. In this situation, tension in the string is $\frac{x}{5}$Mg for x = ____. Neglect mass of the string and friction of the block (bigger mass) with ice slab. (Given g = acceleration due to gravity)



[28-Jun-2022-Shift-1]

Answer: 6

Solution:

Solution:
$a = \frac{Mg}{4M + M} = \frac{g}{5}$ (in upward direction)
$T = M\left(g + \frac{g}{5}\right) = \frac{6Mg}{5}$
$\Rightarrow x = 6$

Question51

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

Options:

A. zero

B. $1.5 ms^{-1}$

C. $2.0 ms^{-1}$

D. $2.5 ms^{-1}$

Answer: C

Solution:

Solution:

$F = -12x$

$mv\frac{dv}{dx} = -12x$

$\int_4^v v\,dv = -6\int_{0.5}^{1.5} x\,dx (m = 2\,kg)$

$\frac{v^2 - 16}{2} = -6\left[\frac{1.5^2 - 0.5^2}{2}\right]$

$\frac{v^2 - 16}{2} = -6$

$v = 2m / sec$

Question52

A wire of length L is hanging from a fixed support. The length changes to L_1 and L_2 when masses 1 kg and 2 kg are suspended respectively from its free end. Then the value of L is equal to :
[29-Jun-2022-Shift-1]

Options:

A. $\sqrt{L_1L_2}$

B. $\frac{L_1 + L_2}{2}$

C. $2L_1 - L_2$

D. $3L_1 - 2L_2$

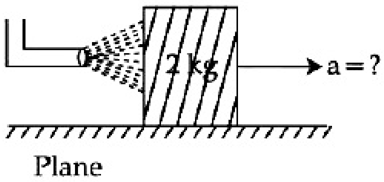
Answer: C

Solution:

Solution:
By Hooke's Law
so $F \alpha \Delta L$
$\frac{F_1}{F_2} = \frac{\Delta L_1}{\Delta L_2}$
$\frac{10}{20} = \frac{(L_1 - L)}{(L_2 - L)}$
$L = 2L_1 - L_2$

Question53

A block of metal weighing 2 kg is resting on a frictionless plane (as shown in figure). It is struck by a jet releasing water at a rate of $1 kgs^{-1}$ and at a speed of $10 ms^{-1}$. Then, the initial acceleration of the block, in ms^{-2}, will be :



[29-Jun-2022-Shift-1]

Options:

A. 3

B. 6

C. 5

D. 4

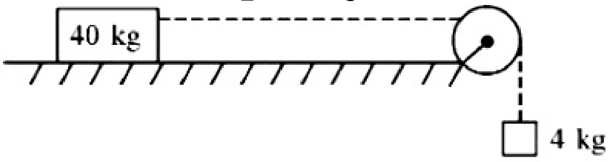
Answer: C

Solution:

Solution:
$F = \rho v^2 a$
$\Rightarrow 10 \times 1 = 2 \times$ acceleration
$\Rightarrow$ Acc. $= 5 m / s^2$

Question54

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 $g = 10 ms^{-2}$.)

[29-Jun-2022-Shift-2]

Options:

A. $1 ms^{-2}$

B. $1 / 5 ms^{-2}$

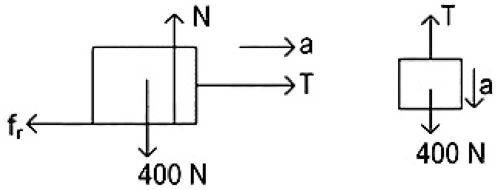
C. $4 / 5 ms^{-2}$

D. $8 / 11 ms^{-2}$

Answer: D

Solution:

Solution:



$f_{r_{max}} = \mu N$
$= 0.02 \times 400$
$= 8N$

Let the acceleration is a as shown then.

$40 - T = 4a$

$T - 8 = 40a$

$\Rightarrow a = \frac{32}{44} = \frac{8}{11} m / s^2$

Question55

A block of mass M placed inside a box descends vertically with acceleration 'a'. The block exerts a force equal to one-fourth of its weight on the floor of the box. The value of 'a' will be [29-Jun-2022-Shift-2]

Options:

A. $\frac{g}{4}$

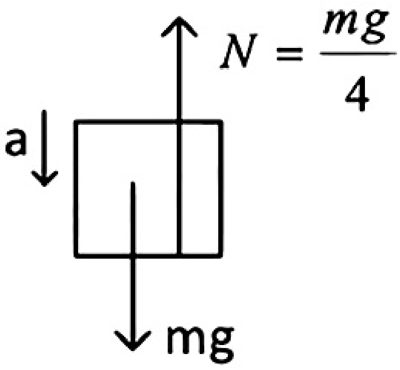
B. $\frac{g}{2}$

C. $\frac{3g}{4}$

D. g

Answer: C

Solution:



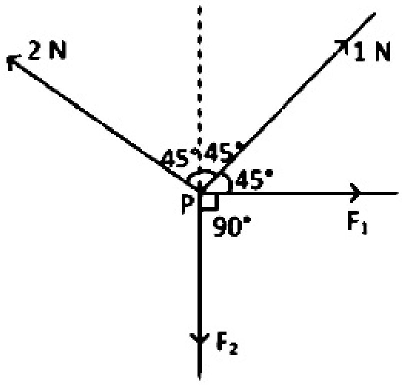
Using Newton's second law

$mg - \frac{mg}{4} = ma$

$\Rightarrow a = \frac{3g}{4}$

Question56

Four forces are acting at a point P in equilibrium as shown in figure. The ratio of force F_1 to F_2 is 1 : x where x =



[25-Jul-2022-Shift-1]

Options:

A. Your Answer :

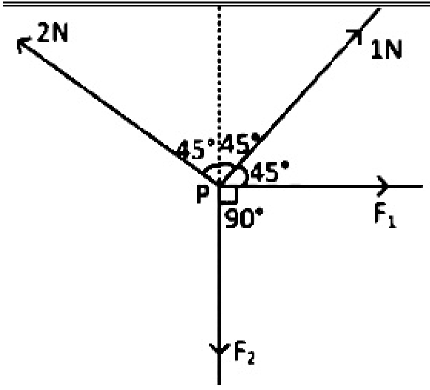
Answer: None

Solution:

Solution:

$F_1 = +2 \times \frac{1}{\sqrt{2}} - \frac{1}{\sqrt{2}} = \frac{1}{\sqrt{2}}$

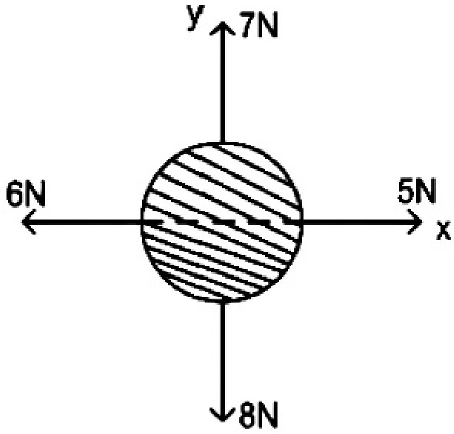
$F_2 = 2 \times \frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}} = \frac{3}{\sqrt{2}}$



$\frac{F_1}{F_2} = \frac{1}{3} = \frac{1}{x} \Rightarrow x = 3$

Question57

For a free body diagram shown in the figure, the four forces are applied in the ' x ' and ' y ' directions. What additional force must be applied and at what angle with positive x-axis so that the net acceleration of body is zero?



[25-Jul-2022-Shift-2]

Options:

A. $\sqrt{2}N , 45^{\circ}$

B. $\sqrt{2}N , 135^{\circ}$

C. $\frac{2}{\sqrt{3}}N , 30^{\circ}$

D. $2N , 45^{\circ}$

Answer: A

Solution:

Solution:

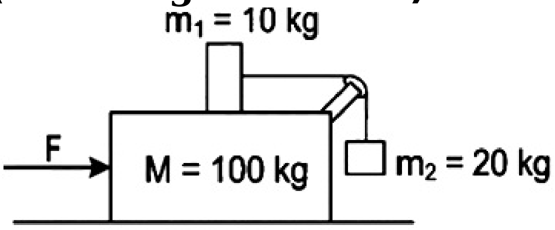
Resultant of already applied forces $= -\hat{i} - \hat{j}$
$\Rightarrow$ Force required to balance $= \hat{i} + \hat{j}$
$\Rightarrow$ Force required $= \sqrt{2}N$ in magnitude at angle 45° with +ve x-axis

---

Question58

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 surfaces 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 $2ms^{-2}$. The value of F is :

(. Take .g = $10 ms^{-2}$)



[26-Jul-2022-Shift-1]

Options:

A. 3360 N

B. 3380 N

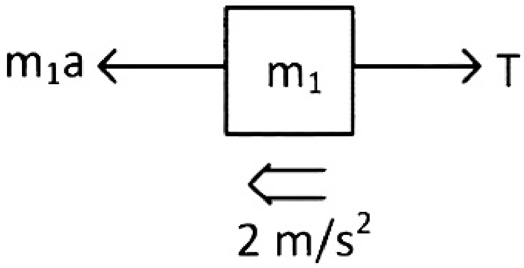
C. 3120 N

D. 3240 N

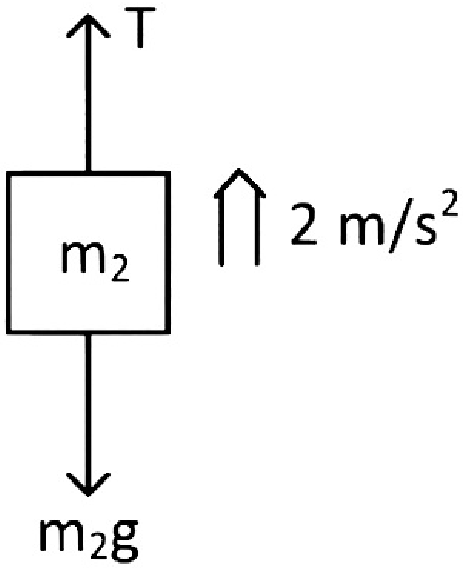
Answer: C

Solution:

Solution:
In frame of block of mass M moving with acceleration a



$m_1a - T = 2m_1 \Rightarrow 10a - T = 20$



$T - m_2g = m_22 \Rightarrow T - 200 = 40 \Rightarrow T = 240$...... (ii)

⇒ From equation 1 and $210a = 260$ or $a = 26 m/s^2$ for block

$F (M + m_2)a = 120 \times 26$

$= 3120N$

Question59

A monkey of mass 50 kg climbs on a rope which can withstand the tension (T) of 350N. If monkey initially climbs down with an acceleration of $4m/s^2$ and then climbs up with an acceleration of $5m/s^2$. Choose the correct option ($g = 10m/s^2$).
[26-Jul-2022-Shift-1]

Options:

A. T = 700N while climbing upward

B. T = 350N while going downward

C. Rope will break while climbing upward

D. Rope will break while going downward

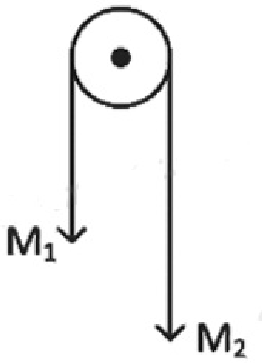
Answer: C

Solution:

Solution:
$T_{down} = 50 \times (10 - 4)$
$= 50 \times 6$
$= 300N$
$T_{up} = 50 \times (10 + 5)$
$= 50 \times 15$
$= 750N$
⇒ Rope will break while climbing up.

Question60

Two masses M_1 and M_2 are tied together at the two ends of a light inextensible string that passes over a frictionless pulley. When the mass M_2 is twice that of M_1, the acceleration of the system is a_1 When the mass M_2 is thrice that of M_1, the acceleration of the system is a_2. The ratio $\frac{a_1}{a_2}$ will be :



[26-Jul-2022-Shift-2]

Options:

A. $\frac{1}{3}$

B. $\frac{2}{3}$

C. $\frac{3}{2}$

D. $\frac{1}{2}$

Answer: B

Solution:

Solution:
Case 1
$a = \frac{m_2 g - m_1 g}{m_1 + m_2}$
$M_2 = 2m_1$
$a_1 = \frac{2m_1 g - m_1 g}{3m_1}$
$a_1 = g / 3$
Case -2
$M_2 = 3m_1$
$a_2 = \frac{3m_1 g - m_1 g}{4m_1}$
$a_2 = \frac{g}{2}$
$\frac{a_1}{a_2} = \frac{\frac{g}{3}}{\frac{g}{2}} = \frac{2}{3}$

Question61

A bag is gently dropped on a conveyor belt moving at a speed of 2m / s. The coefficient of friction between the conveyor belt and bag is 0.4. Initially, the bag slips on the belt before it stops due to friction. The distance travelled by the bag on the belt during slipping motion, is : [Take g = 10m / s^{-2}]
[27-Jul-2022-Shift-1]

Options:

A. 2m

B. 0.5m

C. 3.2m

D. 0.8 ms

Answer: B

Solution:

Solution:
$v = 2m / s$
$\mu = 0.4$

$a = +(0.4)(g)$
$= +4m / s^2$
$v^2 - u^2 = 2\ as$
$\Rightarrow (4) = 2 \times (4)(s)$
$s = 0.5m$

Question62

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 :
[27-Jul-2022-Shift-2]

Options:

A. Mg

B. $Mg\cos\theta$

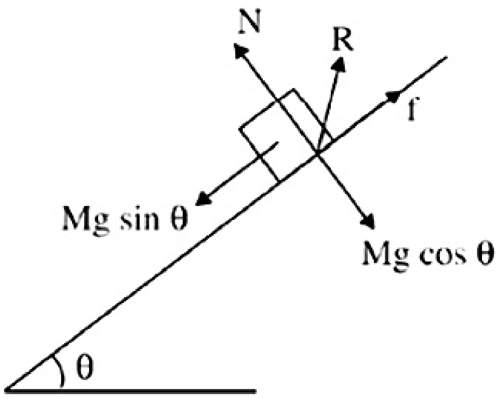
C. $\sqrt{Mg\sin\theta + Mg\cos\theta}$

D. $Mg\sin\theta\sqrt{1+\mu}$

Answer: A

Solution:

Solution:



$N = Mg\cos\theta$
$f = Mg\ \sin\theta$
$R = \sqrt{N^2 + f^2}$
$R = Mg$

Question63

A block 'A' takes 2s to slide down a frictionless incline of 30° and length 'I', kept inside a lift going up with uniform velocity 'v'. If the incline is changed to 45°, the time taken by the block, to slide down the incline, will be approximately :
[27-Jul-2022-Shift-2]

Options:

A. 2.66s

B. 0.83s

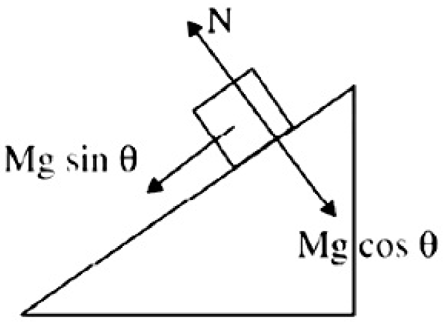
C. 1.68s

D. 0.70s

Answer: C

Solution:

Solution:



$a = g\sin\theta$
$\ell = \frac{1}{2} g \sin 30^\circ (2)^2$
$\ell = \frac{1}{2} g \sin 45^\circ t^2$
$\left(\frac{1}{2}\right)(4) = \frac{1}{\sqrt{2}} t^2 \Rightarrow t = \sqrt{2\sqrt{2}} \simeq 1.68$

Question64

In two different experiments, an object of mass 5 kg moving with a speed of $25 ms^{-1}$ hits two different walls and comes to rest within (i) 3 second, (ii) 5 seconds, respectively. Choose the correct option out of the following :
[28-Jul-2022-Shift-1]

Options:

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

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

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

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

Answer: B

Solution:

Solution:
Impulse = change in momentum
$I = \Delta P$

$F_{aug} = \Delta P / \Delta t$

$\Delta t_1 = 3 \quad \Delta t_2 = 5$

$\Delta P_1 = \Delta P_2$

$I_1 = I_2$

F_{avg}
in case (i) is more than (ii)

Question65

A balloon has mass of 10g in air. The air escapes from the balloon at a uniform rate with velocity 4.5 cm / s. If the balloon shrinks in 5s completely. Then, the average force acting on that balloon will be (in dyne).
[28-Jul-2022-Shift-1]

Options:

A. 3

B. 9

C. 12

D. 18

Answer: B

Solution:

Solution:

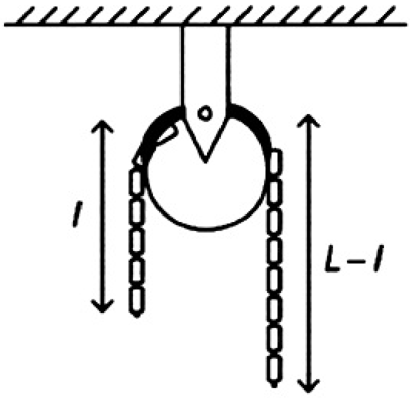
$F = \frac{dm}{dt}v$

$= \frac{10g}{5\ s}\left(4.5\ \frac{cm}{s}\right) = 9\ \frac{gcm}{s^2} = 9$ dyne

----

Question66

A uniform metal chain of mass m and length 'L' passes over a massless and frictionless pulley. It is released from rest with a part of its length 'l' is hanging on one side and rest of its length ' L − l ' is hanging on the other side of the pully. At a certain point of time, when l = $\frac{L}{x}$, the acceleration of the chain is $\frac{g}{2}$. The value of x is ________.



[28-Jul-2022-Shift-2]

Options:

A. 6

B. 2

C. 1.5

D. 4

Answer: D

Solution:

Solution:

$a = \frac{m_2 - m_1}{m_1 + m} g = \frac{g}{2}$

$\Rightarrow m_2 = 3m_1$

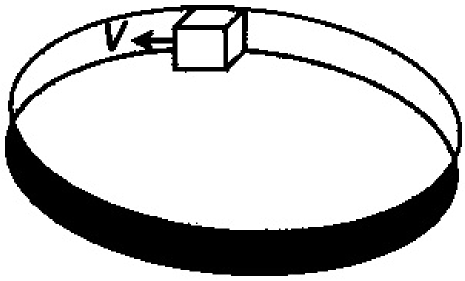
$(L - l) = 3l$

$L = 4l$

$l = \frac{L}{4}$

Question67

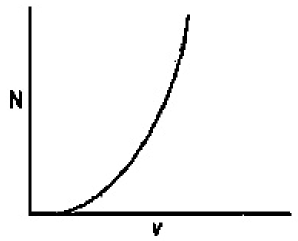
A smooth circular groove has a smooth vertical wall as shown in figure. A block of mass m moves against the wall with a speed v. Which of the following curve represents the correct relation between the normal reaction on the block by the wall (N) and speed of the block (v)?



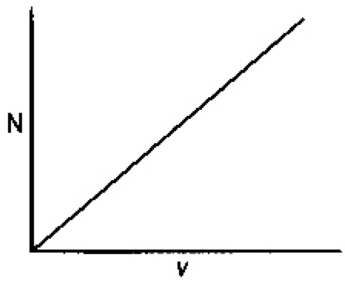
[29-Jul-2022-Shift-1]

Options:

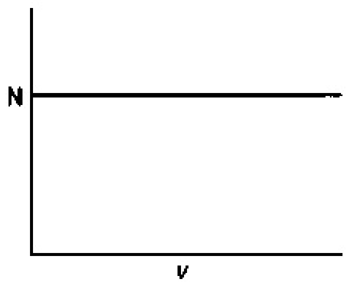
A.



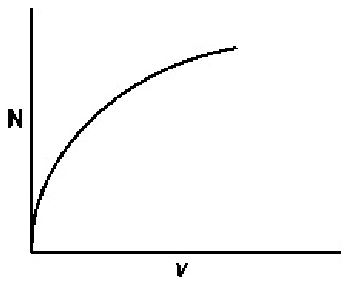
B.



C.



D.



Answer: A

Solution:

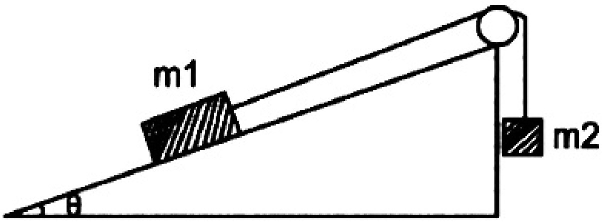
Solution:

$N = \frac{mv^2}{r}$

⇒ The graph given in option A suits the best for the above relation.

Question68

Two bodies of masses $m_1 = 5$ kg and $m_2 = 3$ kg are connected by a light string going over a smooth light pulley on a smooth inclined plane as shown in the figure. The system is at rest. The force exerted by the inclined plane on the body of mass m_1 will be : [. Take .$g = 10ms^{-2}$]



[29-Jul-2022-Shift-2]

Options:

A. 30N

B. 40N

C. 50N

D. 60N

Answer: B

Solution:

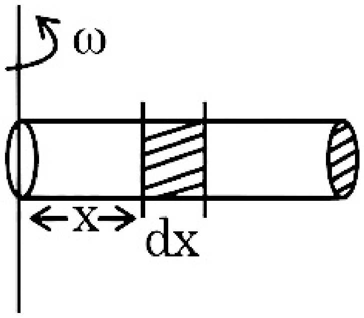
Solution:
Force on equilibrium, $m_2 g = m_1 g \sin\theta$
Normal force on m_1, $N = m_1 g \cos\theta$
$\Rightarrow \frac{N}{m_2 g} = \cot\theta$
$\Rightarrow N = 3 \times 10 \times \cot\theta = 3 \times 10 \times \frac{4}{3} \left(\because \sin\theta = \frac{3}{5}\right)$
$\Rightarrow N = 40N$

Question69

A tube of length 50 cm is filled completely with an incompressible liquid of mass 250g and closed at both ends. The tube is then rotated in horizontal plane about one of its ends with a uniform angular velocity $x\sqrt{F}\ rads^{-1}$. If F be the force exerted by the liquid at the other end then the value of x will be ________.
[29-Jul-2022-Shift-2]

Answer: 4

Solution:



$F = \int (dm)\omega^2 x$

$= \int_0^L \left(\frac{m}{L}dx\right)\omega^2 x$

$= \frac{m}{L}\omega^2 \frac{L^2}{2}$

$= \frac{m\omega^2 L}{2}$

$\omega = \sqrt{\frac{2}{mL}}\sqrt{F}$

$= \sqrt{\frac{2}{0.25 \times 0.5}}\sqrt{F}$

$= \sqrt{16}\sqrt{F}$

$= 4\sqrt{F}$

Question70

A boy pushes a box of mass 2kg with a force $F = \left(20i + 10\hat{j}\right)$ N on a frictionless surface. If the box was initially at rest, then .... m is displacement along the X -axis after 10s.
[26 Feb 2021 Shift 1]

Answer: 500

Solution:

Solution:
Given, mass of box, $m = 2kg$

Force, $F = 20\hat{i} + 10\hat{j}N$
Initial speed of box, $u = 0ms^{-1}$
Time, $t = 10s$
Let acceleration of box is a and displacement along X -axis after 10s is S_x.
As, $F = ma$

$\Rightarrow a = F / m = \frac{20\hat{i} + 10\hat{j}}{2} = \left(10\hat{i} + 5\hat{j}\right) ms^{-2}$
By second equation of motion along X -axis,
$s_x = u_x t + \frac{1}{2}a_x t^2$

$s_x = 0 + \frac{1}{2} \times 10 \times (10)^2 = 500m$
Hence, displacement along X -axis after 10s is 500m.

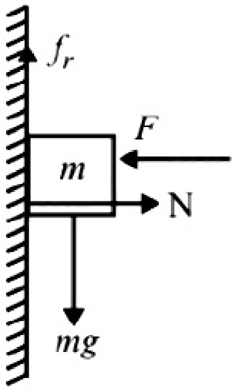
Question71

The coefficient of static friction between a wooden block of mass 0.5kg 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 = $10ms^{-2}$]
[24feb2021shift1]

Answer: 25

Solution:

Solution:
F.B.D. of the block is shown in the diagram



Since, block is at rest,
$\therefore f_r - mg = 0$
$F - N = 0$
$f_r \mu N$
In limiting case,
$f_r = \mu N = \mu F$
Using equation (i) and (iii),
$F = \frac{mg}{\mu}$
$\Rightarrow F = \frac{0.5 \times 10}{0.2} = 25N$

Question72

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 μ = 0.5, the maximum height in cm at which a stationary block will not slip downward is_____cm
[24feb2021shift1]

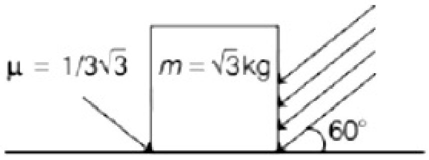
Answer: 25

Solution:

Block will experience maximum force due to friction when it is at maximum height, h at this height, if slope of the tangent is $\tan\theta$, then $\theta =$ Angle of repose. $\therefore \tan\theta = \frac{dy}{dx} = \frac{d}{dk}\left(\frac{x^2}{4}\right) = \frac{x}{2} = 0.5 \Rightarrow x = 1$ and therefore $y = 0.25\text{m} = 25\text{cm}$ (Assuming that x&y in the equation are given in meter)

Question73

As shown in the figure, a block of mass $\sqrt{3}$kg is kept on a horizontal rough surface of coefficient of friction $1/3\sqrt{3}$. 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 .... $\left[g = 10\text{ms}^{-2}; \sin 60^\circ = \frac{\sqrt{3}}{2} \cos 60^\circ = \frac{1}{2}\right]$

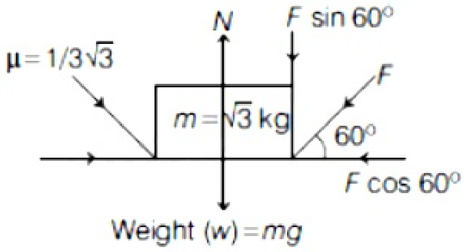


[26 Feb 2021 Shift 1]

Answer: 3.33

Solution:

Solution:
Given, mass of block, $m = \sqrt{3}\text{kg}$
Coefficient of friction, $\mu = 1/3\sqrt{3}$
According to diagram,



Let F be the force applied on the body,
w be the weight ($= mg$),
N be the normal reaction.
Friction force $f = \mu N$
For no movement of body along X-axis, net force along X-axis should be zero.

If, F_y be the net force along y-axis then it will also be zero because body is not accelerating at all.

$\therefore N = F \sin 60^\circ + mg$

$\Rightarrow N = \frac{\sqrt{3}}{2}F + 10\sqrt{3}$ . . . (i)

$\therefore N = F \sin 60^\circ$

$\Rightarrow N = \frac{\sqrt{3}}{2}F + 1$

Similarly, $F_x = F \cos 60^\circ - \mu N = 0$

From Eq. (i), we get

$\Rightarrow \frac{F}{2} - \frac{1}{3\sqrt{3}}\left(\frac{\sqrt{3}}{2}F + 10\sqrt{3}\right) = 0$

$\Rightarrow \frac{F}{2} = \frac{F}{6} + \frac{10}{3} \Rightarrow \frac{F}{2} - \frac{F}{6} = \frac{10}{3}$

$\Rightarrow F = 10N$

Given, $F = 3x$

$\Rightarrow x = \frac{10}{3} = 3.33$

Question74

A particle is moving with uniform speed along the circumference of a circle of radius R under the action of a central fictitious force F which is inversely proportional to R^3. Its time period of revolution will be given by
[26 Feb 2021 Shift 1]

Options:

A. $T \propto R^2$

B. $T \propto R^{3/2}$

C. $T \propto R^{5/2}$

D. $T \propto R^{4/3}$

Answer: A

Solution:

Solution:

Given, radius of circle $= R$

Central fictitious force is, $F \propto \frac{1}{R^3}$.

Let T be the time period of revolution, m, ω be the mass and angular velocity of Earth.

$\because F = m\omega^2 R \propto \frac{1}{R^3}$

$\Rightarrow \omega^2 \propto \frac{1}{R^4} \Rightarrow \omega = \frac{2\pi}{T} \propto \frac{1}{R^2}$

$\Rightarrow T \propto R^2$

Question75

A bullet of mass 0.1kg is fired on a wooden block to pierce through it, but it stops after moving a distance of 50cm into it. If the velocity of

bullet before hitting the wood is 10m / s and it slows down with uniform deceleration, then the magnitude of effective retarding force on the bullet is xN . The value of x to the nearest integer is ……… .
[18 Mar 2021 Shift 1]

Answer: 10

Solution:

Solution:
Given
The mass of the bullet, $m = 0.1kg$
The initial velocity of the bullet before hitting the wooden, $u = 10m / s$
The final velocity of the bullet after hitting the wooden, $v = 0$
The distance travelled by the bullet before coming to the rest, $s = 50cm$
Using the equation of the motion,
$v^2 - u^2 = 2as$
$\Rightarrow\ 0^2 - (10)^2 = 2a(0.50)$
$\Rightarrow\ a = -100m / s^2$
The uniform retardation of the bullet is $100m / s^2$
The magnitude of the effective retarding force on the bullet,
$F\ = ma\ F\ = 0.1(-100)$
$F\ = -10N$
Hence, the value of x to the nearest integer is 10 .

Question76

A body of mass 2kg moves under a force of $\left(2\hat{i} + 3\hat{j} + 5\hat{k}\right)$ N . It starts from rest and was at the origin initially. After 4s, its new coordinates are (8, b, 20). The value of b is
(Round off to the nearest integer)
[16 Mar 2021 Shift 2]

Answer: 12

Solution:

Solution:
Given
Force, $F\ = \left(2\hat{i} + 3\hat{j} + 5\hat{k}\right)N$
Mass, $m = 2kg$
Time, $t = 4s$
We know that
Force = mass × acceleration
$\Rightarrow\ F\ = m \times a \Rightarrow a = \frac{F}{m}$
$\Rightarrow\ a = 2\hat{i} + 3\hat{j} + 5\frac{\hat{k}}{2}$.....(i)

From second equation of motion,

$s = ut + \frac{1}{2}at^2$...(ii)

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

$s = ut + \frac{1}{2}\left(2\hat{i} + 3\hat{j} + 5\frac{\hat{k}}{2}\right) \cdot t^2$

$= 0 + \frac{1}{4}\left(2\hat{i} + 3\hat{j} + 5\hat{k}\right) \cdot (4)^2$ [$\because u = 0$ and $t = 4s$]

$= 0 + 8\hat{i} + 12\hat{j} + 20\hat{k} = 8\hat{i} + 12\hat{j} + 20\hat{k}$

Let $s = x\hat{i} + y\hat{j} + z\hat{k}$

$\Rightarrow x\hat{i} + y\hat{j} + z\hat{k} = 8\hat{i} + 12\hat{j} + 20\hat{k}$ .....(iii)

According to question,new coordinates are $(8, b, 20)$, it means

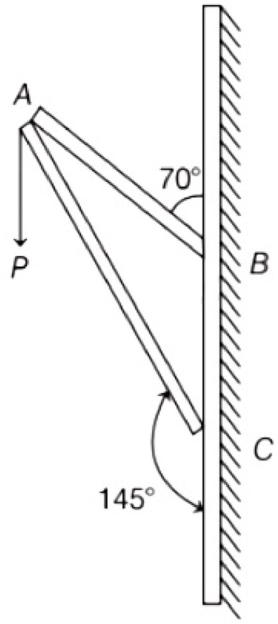
$x\hat{i} + y\hat{j} + z\hat{k} = 8\hat{i} + b\hat{j} + 20\hat{k}$......(iv)

Comparing Eqs. (iii) and (iv), we get

$b = 12$

Question77

Consider a frame that is made up of two thin massless rods AB and AC as shown in the figure. A vertical force P of magnitude 100N is applied at point A of the frame.

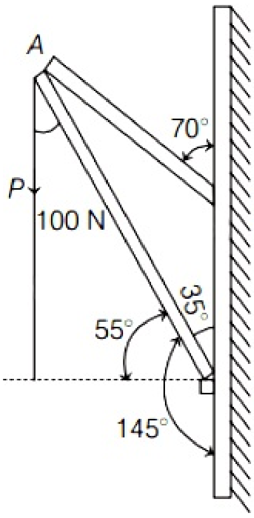


[16 Mar 2021 Shift 1]

Answer: None

Solution:

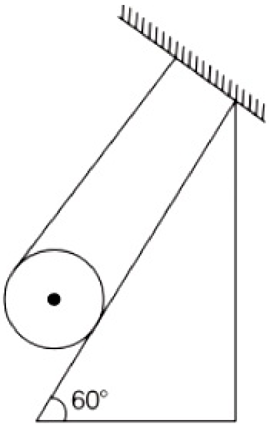
Solution:
If the force P of magnitude 100N is resolved parallel to the arms AB and AC of the frame, the above figure will be represented as follows



Component of force along AC = $100 \cos 35^\circ$ N
$= 100 \times 0.819\text{N} = 81.9\text{N} \approx 82\text{N}$
This is the required magnitude of the resolved component along the arm AC.
Compare with given in question, $x = 82$

Question78

A solid cylinder of mass m is wrapped with an inextensible light string and, is placed on a rough inclined plane as shown in the figure. The frictional force acting between the cylinder and the inclined plane is(The coefficient of static friction, μ_s, is 0.4)



[18 Mar 2021 Shift 2]

Options:

A. $\frac{7}{2}$mg

B. 5mg

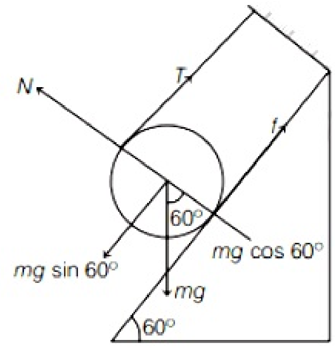
C. $\frac{mg}{r}$

D. 0

Answer: C

Solution:

Solution:
Let's draw the free body diagram of the solid cylinder.



Using the condition of the equilibrium of the cylinder;
In the direction of inclined plane,
$T + f - mg\sin 60^\circ = 0$
In the perpendicular direction of inclined plane, In the perpendicular direction of inclined plane,
$N - mg\cos 60^\circ = 0$
$\Rightarrow N = mg\cos 60^\circ$
The frictional force between the rough surface and cylinder is
$f = \mu_s N$
$\Rightarrow f = 0.4mg\cos 60^\circ \Rightarrow f = 0.2mg$
or $f = \frac{mg}{5}$

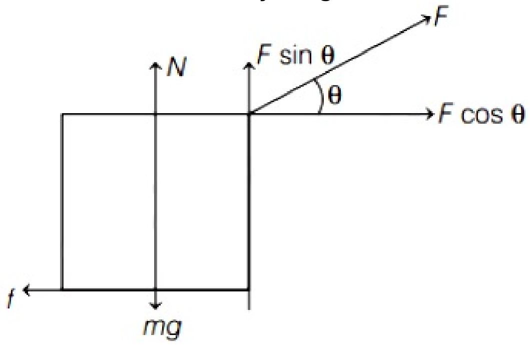
Question79

A body of mass 1kg 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 newton. The value of F will be (Round off to the nearest integer) (Take, $g = 10ms^{-2}$)
[17 Mar 2021 Shift 2]

Answer: 5

Solution:

Solution:
Given, mass of the body, $m = 1kg$
Coefficient of static friction, $\mu = 1/\sqrt{3}$
Let's draw the free body diagram of the block



Using the condition of the equilibrium
In x-direction,
$F\cos\theta = f = \varphi = \mu N$ ...(i)
In y-direction,
$F\sin\theta + N = mg$
$\Rightarrow N = mg - F\sin\theta$....(ii)
Substituting the value of N in Eq. (i), we get

$F = \frac{\mu mg}{\cos\theta + \mu \sin\theta} \Rightarrow F = \frac{\mu mg}{\sqrt{1+\mu^2}}$

Substituting the values in the above equation, we get

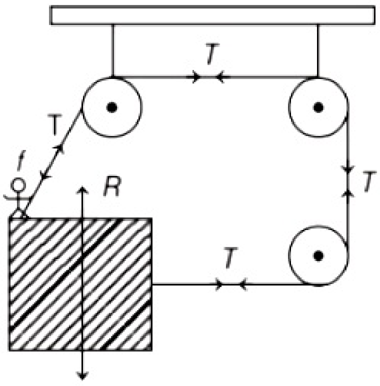
$F = \frac{\frac{1}{\sqrt{3}} \times 10}{\sqrt{1+\left(\frac{1}{\sqrt{3}}\right)^2}} \Rightarrow F = 5N$

Hence, the body move by applying minimum possible force of $5N$.

So, the value of F will be 5 .

Question80

A boy of mass 4kg is standing on a piece of wood having mass 5kg. 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 = $10ms^{-2}$)



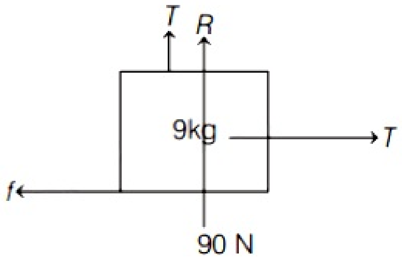
[17 Mar 2021 Shift 2]

Answer: 30

Solution:

Solution:

The free body diagram for the wooden block is shown below



Using the condition of the equilibrium,

In the x-direction, the summation of all the forces is to be zero.

$f - T = 0$

$\mu R - T = 0$

$T = 0.5R$...(i)

In the y-direction, , the summation of all the forces is to be zero.

$T + R - 90 = 0$

$\Rightarrow 0.5R + R - 90 = 0$

$R = 60N$

Hence, the normal force on the wooden block is $60N$

Using the Eq. (i),

$T = 0.5(60) = 30N$
Hence, the maximum value of the tension in the rope,
so that wooden block will not move is $30N$.

Question81

Two blocks ($m = 0.5kg$ and $M = 4.5kg$) 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, $g = 9.8ms^{-2}$)
[17 Mar 2021 Shift 1]

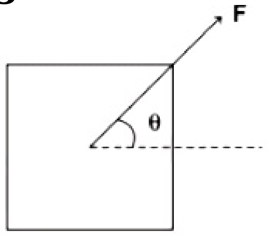
Answer: 21

Solution:

Solution:
When both the blocks move together as a system, then acceleration of this system will be given as
$a = \frac{F}{m + M}$...(i)
Frictional force on mass, $f = ma$...(ii)
From Eqs. (i) and (ii), we get
$f = m\left(\frac{F}{m + M}\right)$
For no slipping, $f \le \mu mg$ [$\because \mu$ being the coefficient of static friction
$\Rightarrow m\left(\frac{F}{m + M}\right) \le \mu mg \Rightarrow F \le \mu(m + M)g$
$\therefore F_{max} = \frac{3}{7}(0.5 + 4.5) \times 9.8 \Rightarrow F_{max} = 21N$

Question82

A block of mass m slides along a floor, while a force of magnitude F is applied to it at an 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)



[16 Mar 2021 Shift 1]

Options:

A. $-\frac{F}{m}\cos\theta - \mu_k\left(g - \frac{F}{m}\sin\theta\right)$

B. $\frac{F}{m}\cos\theta - \mu_k\left(g - \frac{F}{m}\sin\theta\right)$

C. $\frac{F}{m}\cos\theta - \mu_k\left(g + \frac{F}{m}\sin\theta\right)$

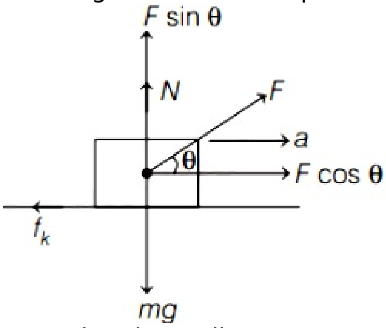
D. $\frac{F}{m}\cos\theta + \mu_k\left(g - \frac{F}{m}\sin\theta\right)$

Answer: B

Solution:

Solution:

The diagram and the required components of force on given block are shown below



From the above diagram,

$N = mg - F\sin\theta$...(i)

where, N = normal force

and $F\cos\theta - f_k = ma$

$\Rightarrow F\cos\theta - \mu_k N = ma$ ...(ii)

where, f_k = kinetic friction force.

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

$F\cos\theta - \mu_k(mg - F\sin\theta) = ma$

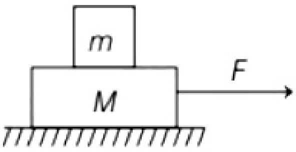
$\Rightarrow a = \frac{F}{m}\cos\theta - \mu_k\left(g - \frac{F}{m}\sin\theta\right)$

This is the required acceleration of the block.

Question83

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, $g = 9.8\text{ms}^{-2}$)



[17 Mar 2021 Shift 1]

Answer: None

Solution:

Solution:
When both the blocks move together as a system, then acceleration of this system will be given as

$a = \frac{F}{m+M}$...(i)

Frictional force on mass, $f = ma$...(ii)

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

$f = m\left(\frac{F}{m+M}\right)$

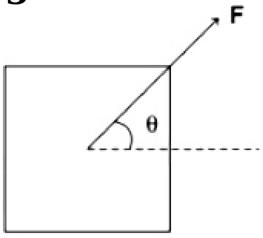
For no slipping, $f \le \mu mg$ [$\because \mu$ being the coefficient of static friction

$\Rightarrow m\left(\frac{F}{m+M}\right) \le \mu mg \Rightarrow F \le \mu(m+M)g$

$\therefore F_{max} = \frac{3}{7}(0.5+4.5) \times 9.8 \Rightarrow F_{max} = 21N$

Question84

A block of mass m slides along a floor, while a force of magnitude F is applied to it at an 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)



[16 Mar 2021 Shift 1]

Options:

A. $-\frac{F}{m}\cos\theta - \mu_k\left(g - \frac{F}{m}\sin\theta\right)$

B. $\frac{F}{m}\cos\theta - \mu_k\left(g - \frac{F}{m}\sin\theta\right)$

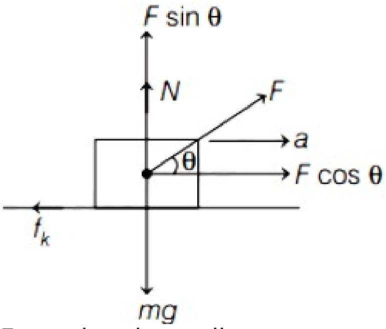
C. $\frac{F}{m}\cos\theta - \mu_k\left(g + \frac{F}{m}\sin\theta\right)$

D. $\frac{F}{m}\cos\theta + \mu_k\left(g - \frac{F}{m}\sin\theta\right)$

Answer: B

Solution:

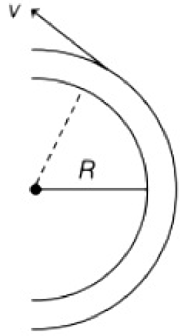
Solution:
The diagram and the required components of force on given block are shown below



From the above diagram,
$N = mg - F\sin\theta$...(i)
where, N = normal force
and $F\cos\theta - f_k = ma$
$\Rightarrow F\cos\theta - \mu_k N = ma$ ...(ii)
where, f_k = kinetic friction force.
From Eq. (i) and Eq. (ii), we get
$F\cos\theta - \mu_k(mg - F\sin\theta) = ma$
$\Rightarrow a = \frac{F}{m}\cos\theta - \mu_k\left(g - \frac{F}{m}\sin\theta\right)$
This is the required acceleration of the block.

Question85

A modern grand-prix racing car of mass m is travelling on a flat track in a circular arc of radius R with a speed v. If the coefficient of static friction between the tyres and the track is μ_s, then the magnitude of negative lift f_L acting downwards on the car is (Assume forces on the four tyres are identical and g = acceleration due to gravity)



[17 Mar 2021 Shift 1]

Options:

A. $m\left(\frac{v^2}{\mu_s R} + g\right)$

B. $m\left(\frac{v^2}{\mu_s R} - g\right)$

C. $m\left(g - \frac{v^2}{\mu_s R}\right)$

D. $-m\left(g + \frac{v^2}{\mu_s R}\right)$

Answer: B

Solution:

Solution:
We know that, static friction force, $f_s = \mu_s N$
where, μ_s is the coefficient of static friction and N is the normal force acting on the body.
As the car is travelling on a circular track, so centripetal force is also acting on it.

$\Rightarrow f_C = \frac{mv^2}{R}$

In limiting condition,

$f_s = f_C \Rightarrow \mu_s N = \frac{mv^2}{R}$

$\Rightarrow N = \frac{mv^2}{\mu_s R}$....(i)

The magnitude of negative lift f_L acting downwards on the car is given by

$f_L = mg - N$

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

$\Rightarrow f_L = m\left(g - \frac{v^2}{\mu_s R}\right) \Rightarrow f_L = -m\left(\frac{v^2}{\mu_s R} - g\right)$

$\Rightarrow |f_L| = m\left(\frac{v^2}{\mu_s R} - g\right)$

Question86

Statement I A cyclist is moving on an unbanked road with a speed of $7 kmh^{-1}$ and takes a sharp circular turn along a path of radius of 2m without reducing the speed. The static friction coefficient is 0.2. The cyclist will not slip and pass the curve ($g = 9.8 m/s^2$) Statement II If the road is banked at an angle of 45°, cyclist can cross the curve of 2m radius with the speed of $18.5 kmh^{-1}$ without slipping. In the light of the above statements, choose the correct answer from the options given below.
[16 Mar 2021 Shift 2]

Options:

A. Statement I is false and statement II is true

B. Statement I is true and statement II is false.

C. Both statement I and statement II are false.

D. Both statement I and statement II are true.

Answer: D

Solution:

Solution:
The maximum speed of cyclist on turn of unbanked road without slipping is given as
$v_{max} = \sqrt{\mu g R} = \sqrt{0.2 \times 10 \times 2} = 2 ms^{-1}$ [$\because \mu = 0.2$ (given)]
Given, speed $= 7 km/h$

$= \frac{7000}{3600} ms^{-1} = \frac{70}{36} = 1.94 ms^{-1}$

As given speed is lesser than v_{max}, so the cyclist will not slip. Therefore, Statement I is true.
As per Statement II, angle of banking, $\theta = 45^\circ$
We know that, for banked road,

$$V_{max} = \sqrt{\frac{gR(\mu + \tan\theta)}{(1 - \mu\tan\theta)}}$$

and $v_{min} = \sqrt{\frac{gR(\tan\theta - \mu)}{1 + \mu\tan\theta}}$

$\Rightarrow v_{max} = \sqrt{\frac{10 \times 2(0.2 + \tan 45^\circ)}{1 - 0.2\tan 45^\circ}}$

and $v_{min} = \sqrt{\frac{10 \times 2(1 - 0.2)}{1 + 0.2}}$

and $v_{min} = \sqrt{\frac{10 \times 2(1 - 0.2)}{1 + 0.2}}$

$\Rightarrow v_{max} = 5.47 ms^{-1}$ and $v_{min} = 3.65 ms^{-1}$

$\because v = 18.5 km/h = \frac{18.5 \times 1000}{5600} = 5.13 ms^{-1}$

[$\because$ given speed $= 18.5 kmh^{-1}$]
As, $v_{min} < v < v_{max}$, so the cyclist will not slip.
$\therefore$ Statement II is also true.
Hence, option (d) is the correct.

Question87

A block of 200g mass moves with a uniform speed in a horizontal circular groove, with vertical side walls of radius 20cm. If the block takes 40 s to complete one round, the normal force by the side walls of the groove is
[16 Mar 2021 Shift 1]

Options:

A. $0.0314 N$

B. $9.859 \times 10^{-2} N$

C. $6.28 \times 10^{-3} N$

D. $9.859 \times 10^{-4} N$

Answer: D

Solution:

Solution:
The normal force by the side walls of the groove will be equal to the centripetal force acting on it.

i.e. $N = \frac{mv^2}{r}$.....(i)

where,
$r = 20 cm = 0.2 m$

$m = 200 g = 200 \times 10^{-3} kg$ and $v = r\omega = \frac{2\pi r}{T} = \frac{2\pi \times 0.2}{40} m/s$

Substituting the given values in Eq. (i), we get

$$N = \frac{(200 \times 10^{-3}) \times \left(\frac{2\pi \times 0.2}{40}\right)^2}{0.2}$$

$\approx 9.859 \times 10^{-4} N$

Question88

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 2T is :
[27 Jul 2021 Shift 2]

Options:

A. $2F_0T / M$

B. $F_0T / 2M$

C. $4F_0T / 3M$

D. $F_0T / 3M$

Answer: C

Solution:

Solution:

$t = 0, u = 0$

$$a = \frac{F_0}{M} - \frac{F_o}{MT^2}(t-T)^2 = \frac{dv}{dt}$$

$$\int_0^v dv = \int_{t=0}^{2T}\left(\frac{F_o}{M} - \frac{F_o}{MT^2}(t-T)^2\right)dt$$

$$V = \left[\frac{F_o}{M}t\right]_0^{2T} - \frac{F_0}{MT^2}\left[\frac{t^3}{3} - t^2T + T^2t\right]_0^{2T}$$

$$V = \frac{4F_0T}{3M}$$

Question89

A force $\vec{F} = \left(40\hat{i} + 10\hat{j}\right)N$ acts on a body of mass 5kg. If the body starts from rest, its position vector $\vec{r}$ at time t = 10s, will be :
[25 Jul 2021 Shift 2]

Options:

A. $\left(100\hat{i} + 400\hat{j}\right)m$

B. $\left(100\hat{i} + 100\hat{j}\right)m$

C. $\left(400\hat{i} + 100\hat{j}\right)m$

D. $\left(400\hat{i} + 400\hat{j}\right)m$

Answer: C

Solution:

Solution:

$\frac{d\vec{v}}{dt} = \vec{a} = \frac{\vec{F}}{m} = (8\hat{i} + 2\hat{j})\, m/s^2$

$\frac{d\vec{r}}{dt} = \vec{v} = (8t\hat{i} + 2t\hat{j})\, m/s$

$\vec{r} = (8\hat{i} + 2\hat{j})\frac{t^2}{2} m$

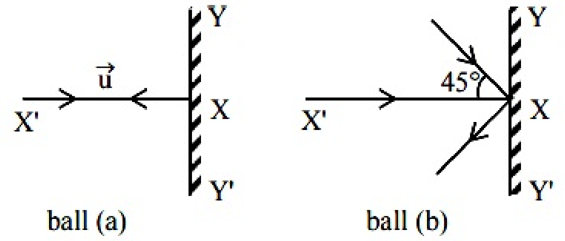
At t = 10sec

$\vec{r} = [(8\hat{i} + 2\hat{j})50] m$

$\Rightarrow \vec{r} = (400\hat{i} + 100\hat{j}) m$

Question90

Two billiard balls of equal mass 30 g strike a rigid wall with same speed of 108 kmph (as shown) but at different angles. If the balls get reflected with the same speed then the ratio of the magnitude of impulses imparted to ball 'a' and ball 'b' by the wall along 'X' direction is :



[25 Jul 2021 Shift 1]

Options:

A. 1 : 1

B. $\sqrt{2}$: 1

C. 2 : 1

D. 1 : $\sqrt{2}$

Answer: B

Solution:

Solution:

Impulse = change in momentum

Ball (a) $|\Delta\vec{p}| = 2mu = J_1$

Ball (b) $|\Delta\vec{p}| = 2mu\cos 45° = J_2$

$\frac{J_1}{J_2} = \frac{1}{\cos 45°} = \sqrt{2}$

Question91

A bullet of ' 4g ' mass is fired from a gun of mass4kg. If the bullet moves with the muzzle speed of50ms^{-1}, the impulse imparted to the gun and velocity of recoil of gun are:
[22 Jul 2021 Shift 2]

Options:

A. $0.4\text{kg} \sim \text{ms}^{-1}$, 0.1ms^{-1}

B. 0.2kgms^{-1}, 0.05ms^{-1}

C. 0.2kgms^{-1}, 0.1ms^{-1}

D. 0.4kgms^{-1}, 0.05ms^{-1}

Answer: B

Solution:

Solution:

By momentum conservation
$4 \times 10^{-3}(50 - v) - 4v = 0$
$v = \dfrac{4 \times 10^{-3} \times 50}{4 + 4 \times 10^{-3}} \approx 0.05\text{ms}^{-1}$
Impulse $J = mv = 4 \times .05 = 0.2\text{kgms}^{-1}$

Question92

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 _______.
[20 Jul 2021 Shift 2]

Solution:

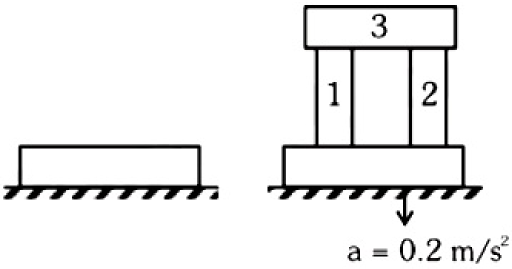
Solution:

$t_a = \dfrac{1}{2}t_d$
$\sqrt{\dfrac{2s}{a_a}} = \dfrac{1}{2}\sqrt{\dfrac{2s}{a_d}}$ ......(i)
$a_a = g\sin\theta + \mu g\cos\theta$

$= \frac{g}{2} + \frac{\sqrt{3}}{2}\mu g$
$a_d = g\sin\theta - \mu g\cos\theta$
$= \frac{g}{2} - \frac{\sqrt{3}}{2}\mu g$
using the above values of a_a and a_d and putting inequtionn (i) we will gate $\mu = \frac{\sqrt{3}}{5}$

Question93

A steel block of 10kg rests on a horizontal floor as shown. When three iron cylinders are placed on it as shown, the block and cylinders go down with an acceleration $0.2 m/s^2$. The normal reaction R′ by the floor if mass of the iron cylinders are equal and of 20kg each, is ______ N. [Take $g = 10 m/s^2$ and $\mu_s = 0.2$]



[20 Jul 2021 Shift 1]

Options:

A. 716

B. 686

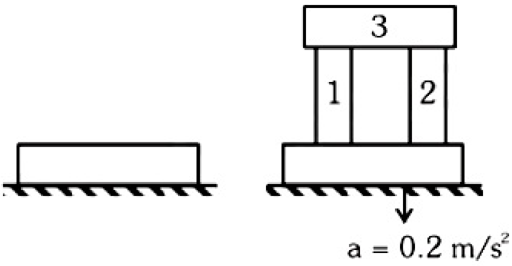
C. 714

D. 684

Answer: B

Solution:

Solution:



Writing force equation in vertical direction
$Mg - N = Ma$
$\Rightarrow 70g - N = 70 \times 0.2$
$\Rightarrow N = 70[g - 0.2] = 70 \times 9.8$
$\therefore N = 686$ Newton
Note : Since there is no compressive normal from the sides, hence friction will not act.
Hence option 2.

Question94

Consider a binary star system of star A and star B with masses m_A and m_B revolving in a circular orbit of radii r_A and r_B, respectively. If T_A and T_B are the time period of star A and star B, respectively, then:
[20 Jul 2021 Shift 2]

Options:

A. $\frac{T_A}{T_B} = \left(\frac{r_A}{r_B}\right)^{\frac{3}{2}}$

B. $T_A = T_B$

C. $T_A T_B$ (if $m_A > m_B$)

D. $T_A > T_B$(if $r_A > r_B$)

Answer: B

Solution:

Solution:
$T_A = T_B$(since $\omega_A = \omega_B$)

Question95

The normal reaction 'N' for a vehicle of 800kg mass, negotiating a turn on a 30° banked road at maximum possible speed without skidding is _______ $\times 10^3$ kgm / s^2
[20 Jul 2021 Shift 1]

Options:

A. 10.2

B. 7.2

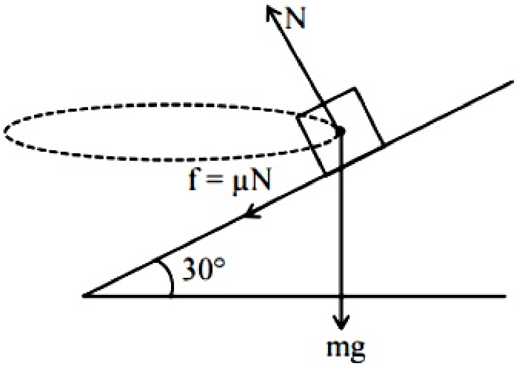
C. 12.4

D. 6.96

Answer: A

Solution:

Solution:



At v_{max}, f will be limiting in nature.
∴ Balancing force in vertical direction,
$N \cos 30° - mg - \mu N \cos 60° = 0$
$\Rightarrow N [\cos 30° - \mu \cos 60°] = mg$
$\therefore N = \frac{800 \times 10}{(0.87 - 0.1)} \approx 10.2 \times 10^3 kgm / s^2$
Hence option 1 .

Question96

The initial mass of a rocket is 1000 kg. Calculate at what rate the fuel should be burnt, so that the rocket is given an acceleration of $20 ms^{-1}$. The gases come out at a relative speed of $500 ms^{-1}$ with respect to the rocket [Use, $g = 10 m / s^2$]
[26 Aug 2021 Shift 1]

Options:

A. $6.0 \times 10^2 kg s^{-1}$

B. $500 kg s^{-1}$

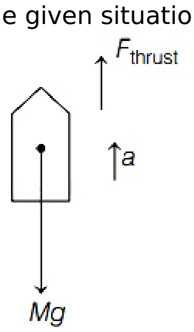
C. $10 kg s^{-1}$

D. $60 kg s^{-1}$

Answer: D

Solution:

Solution:
Given, $M = 1000 kg$, $a = 20 m / s^2$
$v_{relative} = 500 m / s$, $g = 10 m / s^2$
The given situation is shown below



$F_{thrust} = \frac{d}{dt}(M v_{relative})$

$\Rightarrow F_{thrust} = v_{relative} \left(\frac{dM}{dt} \right)$

By Newton's second law of motion,

$\Rightarrow F_{thrust} - Mg = Ma$

$\Rightarrow v_{relative}\left(\frac{dM}{dt}\right) - Mg = Ma$

$\Rightarrow 500\left(\frac{dM}{dt}\right) - 1000 \times 10 = 1000 \times 20$

$\Rightarrow 500\left(\frac{dM}{dt}\right) = 1000(20 + 10)$

$\Rightarrow 500\left(\frac{dM}{dt}\right) = 1000 \times 30$

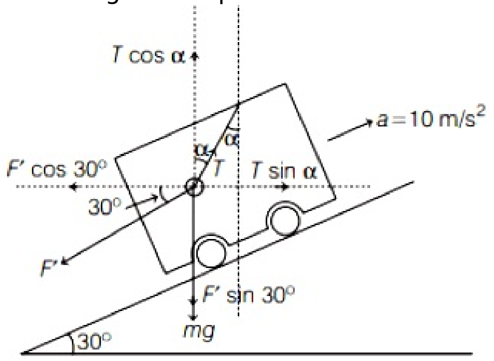
$\Rightarrow \frac{dM}{dt} = \frac{1000 \times 30}{500} = 60$

$\Rightarrow \frac{dM}{dt} = 60\,kg / s$

Question97

A car is moving on a plane inclined at 30° to the horizontal with an acceleration of $10ms^{-2}$ 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 verticalis........
(Take, $g = 10ms^{-2}$)
[31 Aug 2021 Shift 1]

Solution:
Given,
Angle of inclination, θ = 30º
Acceleration, $a = 10ms^{-2}$
Acceleration due to gravity, $g = 10ms^{-2}$
According to the question the car and bob is as shown below,



Here, F' is the pseudo force acting on the bob when we considered it from car’s frame and T is the tension on the string.
In equilibrium, $\Sigma F_x = 0$ and $\Sigma F_y = 0$

$\Rightarrow F' \cos 30° = T \sin \alpha$

$ma \cos 30° \sin \alpha = T$ ...(i)

where, m is the mass of the bob.

$F' \sin 30° + mg = T \cos \alpha$

$\Rightarrow ma \sin 30° + mg = \frac{ma \cos 30°}{\sin \alpha}(\cos \alpha)$ [∵ using Eq. (i)]

$\Rightarrow a \sin 30° + g = \frac{a \cos 30°}{\sin \alpha}(\cos \alpha)$

$10 \times \frac{1}{2} + 10 = \frac{10 \times \sqrt{3}}{2} . \alpha$

$\Rightarrow \frac{1}{2} + 1 = \frac{\sqrt{3}}{2} . \alpha$

$\Rightarrow \frac{3}{2} = \frac{\sqrt{3}}{2} . \alpha$

or $\cot \alpha = \sqrt{3}$

$\Rightarrow \alpha = 30°$

Question98

Statement I If three forces F_1 . F_2 and F_3 are represented by three sides of a triangle and $F_1 + F_2 = -F_3$, then these three forces are concurrent forces and satisfy the condition for equilibrium.
Statement II A triangle made up of three forces F_1, F_2 and F_3 as its sides taken in the same order, satisfy the condition for translatory equilibrium. In the light of the above statements, choose the most appropriate answer from the options given below.
[31 Aug 2021 Shift 2]

Options:

A. Statement I is false but statement II is true.

B. Statement I is true but statement II is false.

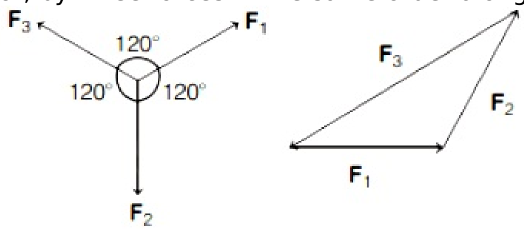
C. Both statement I and statement II are false.

D. Both statement I and statement II are true.

Answer: D

Solution:

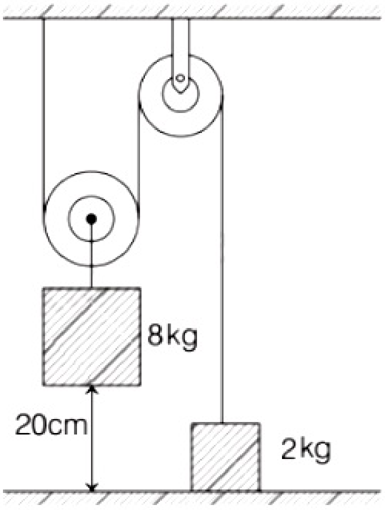
Solution:
Three forces F_1, F_2 and F_3 are acting on a body and if this body is in equilibrium, then resultant of these three forces must be zero i.e.
$F_{net} = F_1 + F_2 + F_3 = 0$
$\Rightarrow F_1 + F_2 = -F_3$
This situation can be shown graphically by three concurrent forces at 120° with each others.
or, by three forces in the same order along three sides of a triangle.



Hence, both statement I and statement II are true.

Question99

The boxes of masses 2 kg and 8 kg are connected by a massless string passing over smooth pulleys. Calculate the time taken by box of mass 8 kg to strike the ground starting from rest.
(Use, $g = 10 m / s^2$)



[27 Aug 2021 Shift 2]

Options:

A. 0.34 s

B. 0.2 s

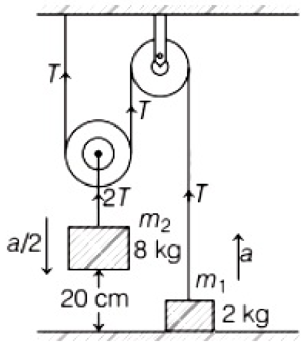
C. 0.25 s

D. 0.4 s

Answer: D

Solution:

Solution:
According to the given figure, and free body diagram



masses of two bodies $m_1 = 2kg m_2 = 8kg$,
Acceleration of mass $m_1 = a$
Acceleration of mass $m_2 = \frac{a}{2}$
Tension $= T$
Distance between m_2 and ground $= 20cm$
$= 0.2m$
Initial velocity $u = 0$
Equation of motion of 2kg block,
$\therefore\ T - 2g = 2a \quad \cdots\cdots (i)$
Equation of motion of 8kg block, and $8g - 2T = 8\frac{a}{2} \Rightarrow 4g - T = 2a \quad \cdots\cdots (ii)$
From Eqs. (i) and (ii),
$\Rightarrow\ T - 2g = 4g - T$
Substituting the value in Eq. (i) we get

$3g - 2g = 2a \Rightarrow g = 2a$

$\Rightarrow a = \frac{g}{2} = 5ms^{-2}$

$\therefore a_1 = 5ms^{-2}$ and $_2 = \frac{5}{2}ms^{-2}$

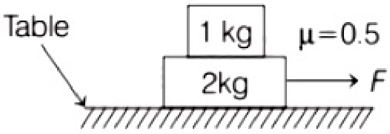
Since, $s = ut + \frac{1}{2}at^2$

$\therefore \frac{20}{100} = 0 + \frac{1}{2}\frac{5}{2} \times t^2 \Rightarrow t^2 = \frac{20 \times 4}{5 \times 100}$

$\Rightarrow t = \frac{2}{5} = 0.4s$

Question100

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, $g = 10ms^{-2}$)

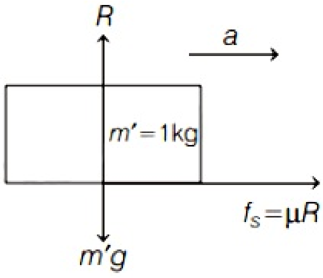


[26 Aug 2021 Shift 2]

Answer: None

Solution:

Solution:
Given, coefficient of static friction, μ = 0.5
Value of acceleration due to gravity, $g = 10ms^{-2}$
For complete system to move together,
F = ma
Here, m is total mass.
F = (1 + 2) a = 3a ...(i)
From free body diagram of 1 kg block,



Balance forces in horizontal direction,
$F_s = \mu R = m'a$ ...(ii)
Balance forces in vertical direction,
R = m′g
Put value of R in Eq. (ii),
μm′g = m′a
⇒ 0.5 × 1 × 10 = 1 × a
$\Rightarrow a = 5ms^{-2}$
Put the value of a in Eq. (i), we get
F = 3 × 5 = 15 N
Thus, the maximum horizontal force required to move block together is 15 N.

Question101

A particle of mass m is suspended from a ceiling through a string of length L. The particle moves in a horizontal circle of radius r such that $r = \frac{L}{\sqrt{2}}$. The speed of particle will be
[26 Aug 2021 Shift 2]

Options:

A. $\sqrt{rg}$

B. $\sqrt{2rg}$

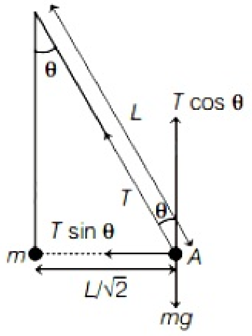
C. $2\sqrt{rg}$

D. $\sqrt{\frac{rg}{2}}$

Answer: A

Solution:

Solution:
Given, radius of horizontal circle, $r = \frac{L}{\sqrt{2}}$
Figure illustrating the particle of mass m moving in a horizontal circle, while suspended from a ceiling is shown



In equilibrium condition at point A,
$T\cos\theta = mg$ ...(i)
$T\sin\theta = \frac{mv^2}{r}$ ...(ii)
Divide Eq. (ii) by Eq. (i),
$\tan\theta = v^2 / rg$
$\Rightarrow v = \sqrt{rg\tan\theta}$ ...(iii)
Now, from figure, we can write
$\sin\theta = \frac{L/\sqrt{2}}{L} = \frac{1}{\sqrt{2}}$
$\Rightarrow \theta = 45°$
Substituting the value of θ in Eq. (iii), we get
$v = \sqrt{rg\tan 45°} = \sqrt{rg}$
Thus, the value of speed of particle is $v = \sqrt{rg}$.

Question102

A particle of mass m is suspended from a ceiling through a string of length L. The particle moves in a horizontal circle of radius r such that $r = \frac{L}{\sqrt{2}}$. The speed of particle will be

[26 Aug 2021 Shift 2]

Options:

A. $\sqrt{rg}$

B. $\sqrt{2rg}$

C. $2\sqrt{rg}$

D. $\sqrt{\frac{rg}{2}}$

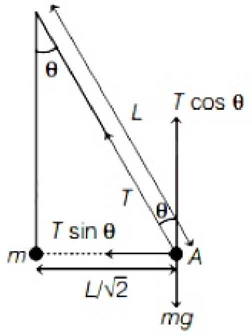
Answer: A

Solution:

Solution:

Given, radius of horizontal circle, $r = \frac{L}{\sqrt{2}}$

Figure illustrating the particle of mass m moving in a horizontal circle, while suspended from a ceiling is shown



In equilibrium condition at point A,
$T\cos\theta = mg$ ...(i)

$T\sin\theta = \frac{mv^2}{r}$ ...(ii)

Divide Eq. (ii) by Eq. (i),
$\tan\theta = v^2 / rg$
$\Rightarrow v = \sqrt{rg\tan\theta}$ ...(iii)
Now, from figure, we can write

$\sin\theta = \frac{L/\sqrt{2}}{L} = \frac{1}{\sqrt{2}}$

$\Rightarrow \theta = 45°$
Substituting the value of θ in Eq. (iii), we get
$v = \sqrt{rg\tan 45°} = \sqrt{rg}$
Thus, the value of speed of particle is $v = \sqrt{rg}$.

Question103

When a body slides down from rest along a smooth inclined plane making an angle of 30° with the horizontal, it takes time T. When the same body slides down from the rest along a rough inclined plane making the same angle and through the same distance, it takes time αT, where α is a constant greater than 1. The coefficient of friction between the body and the rough plane is

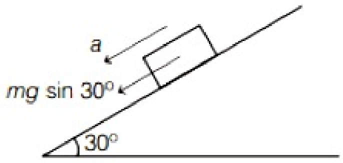
$\frac{1}{\sqrt{x}}\left(\frac{\alpha^2-1}{\alpha^2}\right)$**, where x is ....**

[1 Sep 2021 Shift 2]

Answer: 3

Solution:

Solution:
Let's draw the free body diagram when body slides down on smooth surface



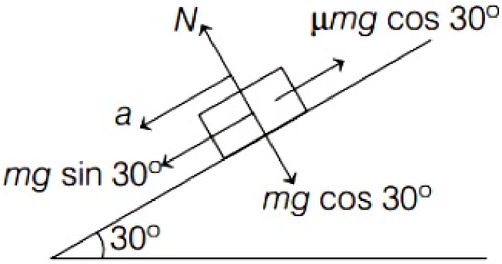
For smooth surface,
ma = mg sin30º
a = g sin30º
a = g / 2
Distance covered by the block on the smooth surface in time T,

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

$s = 0 + \frac{1}{2}\left(\frac{g}{2}\right)T^2$

$\Rightarrow s = \left(\frac{g}{4}\right)T^2$ ...(i)

Now, let's draw the free body diagram when body slides down on rough surface



For rough surface,
ma = mg sin30º - μ mg cos30º
a = g sin30º - μ g
Distance covered by the block on the rough surface in time α T,

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

$s = 0 + \frac{1}{2}(g\sin 30\,º - \mu g \sin 30\,\mu)t^2$

$s = \frac{g}{4}(1 - \sqrt{3}\mu)(\alpha T)^2$ ...(ii)

Distance covered by the block is same for both the case,

$\Rightarrow \frac{g}{4}(1 - \sqrt{3}\mu)(\alpha T)^2 = \frac{g}{4}T^2$[from Eq. (i) & Eq. (ii)]

$\Rightarrow 1 - \sqrt{3}\mu = \frac{1}{\alpha^2}$

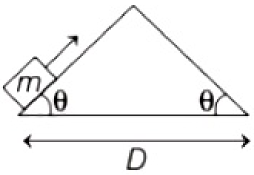
$\Rightarrow \mu = \left(\frac{\alpha^2 - 1}{\alpha^2}\right)\frac{1}{\sqrt{3}}$

Comparing with $\left(\frac{\alpha^2 - 1}{\alpha^2}\right)\frac{1}{\sqrt{x}}$

The value of the x = 3.

Question104

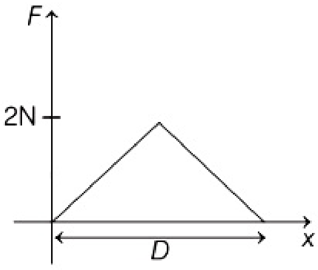
An object of mass m is being moved with a constant velocity under the action of an applied force of 2N along a frictionless surface with following surface profile.



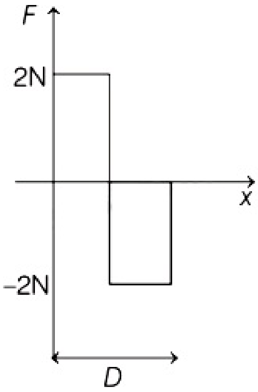
The correct applied force versus distance graph will be
[1 Sep 2021 Shift 2]

Options:

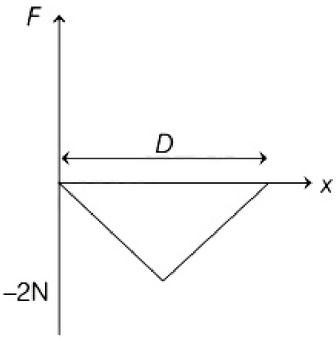
A.



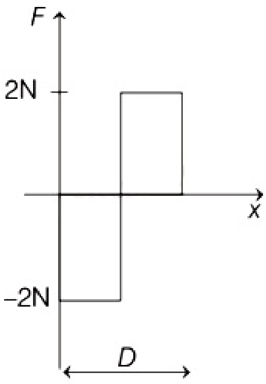
B.



C.



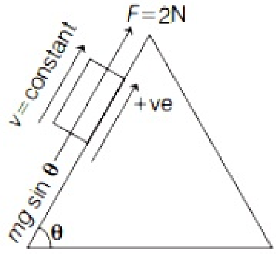
D.



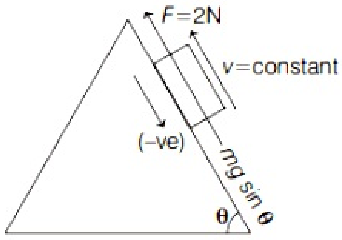
Answer: B

Solution:

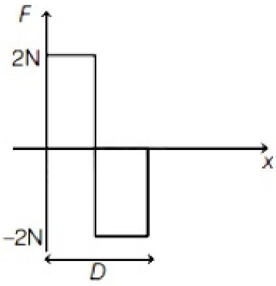
Solution:
Let’s draw the free body diagram,
(During the upward direction)



F = 2N = (+ ve) constant
(During the downward direction)

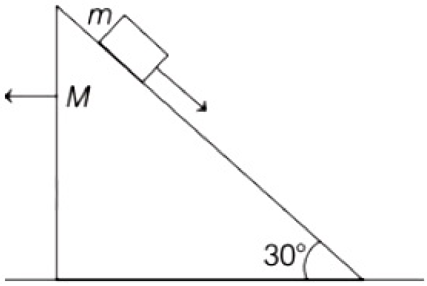


F = 2N = (- ve) constant
During the upward motion, the force is positive constant and during the downward motion the force is negative constant.
Hence, the correct graph is (b).



Question105

A block of mass m slides on the wooden wedge, which in turn slides backward on the horizontal surface. The acceleration of the block with respect to the wedge is
[Given, m = 8 kg, M = 16 kg]
Assume all the surfaces shown in the figure to be frictionless.



[1 Sep 2021 Shift 2]

Options:

A. $\frac{4}{3}g$

B. $\frac{6}{5}$g

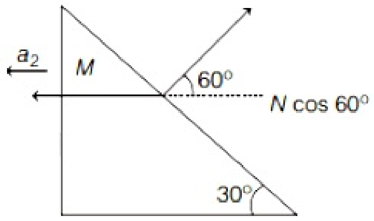
C. $\frac{3}{5}$g

D. $\frac{2}{3}$g

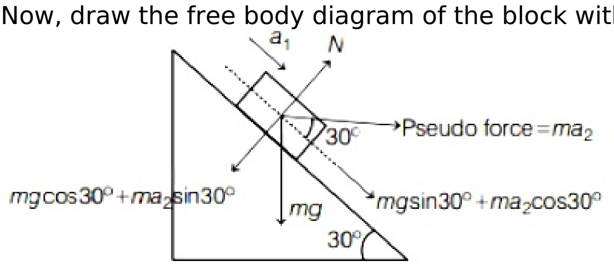
Answer: D

Solution:

Solution:
Here, both block and wedge are moving.
Consider the acceleration of the block with respect to the wedge is a_1 and the acceleration of the wedge is a_2.
Given, mass of the wedge, M = 16 kg
and mass of block, m = 8 kg
Let's draw the free body diagram of the wedge,



In the x-directions,
$N \cos 60^{\circ} = Ma_2$
$N(0.5) = 16 \times a_2$
$\Rightarrow N = 32a_2$
Now, draw the free body diagram of the block with respect to the wedge.



Along the perpendicular to the inclined plane,
$N = 8g \cos 30^{\circ} - 8a2 \sin 30^{\circ}$
$32a_2 = 4\sqrt{3}g - 4a_2$
$36a_2 = 4\sqrt{3}g$
$\Rightarrow a_2 = \frac{\sqrt{3}}{9}g$
Along the inclined plane,
$mg \sin 30^{\circ} + ma_2 \cos 30^{\circ} = ma_1$
$8g \times \frac{1}{2} + 8 \times \frac{\sqrt{3}}{9}g \times \frac{\sqrt{3}}{2} = 8a_1$
$\Rightarrow a_1 = \frac{2g}{3}$
∴ The acceleration of the block with respect to the wedge is $\frac{2g}{3}$.

Question106

A mass of 10 kg is suspended by a rope of length 4 m, from the ceiling. A force F is applied horizontally at the midpoint of the rope such that the top half of the rope makes an angle of 45° with the vertical. Then F equals:
(Take g = 10 ms^{-2} and the rope to be massless)

[7 Jan. 2020 II]

Options:

A. 100 N

B. 90 N

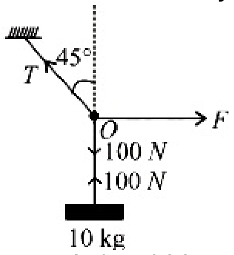
C. 70 N

D. 75 N

Answer: A

Solution:

Solution:
From the free body diagram



$T\cos 45° = 100N$ ......(i)
$T\sin 45° = F$ ....(ii)
On dividing (i) by (ii) we get
$\frac{T\cos 45°}{T\sin 45°} = \frac{100}{F}$
$\Rightarrow F = 100N$

Question107

An elevator in a building can carry a maximum of 10 persons, with the average mass of each person being 68 kg. The mass of the elevator itself is 920 kg and it moves with a constant speed of 3 m/s. The frictional force opposing the motion is 6000 N. If the elevator is moving up with its full capacity, the power delivered by the motor to the elevator ($g = 10\ m/s^2$) must be at least:
[7 Jan. 2020 II]

Options:

A. 56300 W

B. 62360 W

C. 48000 W

D. 66000 W

Answer: D

Solution:

Solution:
Net force on the elevator = force on elevator + frictional force
$\Rightarrow F = (10m + M)g + f$
where, $m =$ mass of person, $M =$ mass of elevator, $f =$ frictional force
$\Rightarrow F = (10 \times 68 + 920) \times 9.8 + 600$
$\Rightarrow F = 22000N$
$\Rightarrow P = FV = 22000 \times 3 = 66000W$

Question108

A particle moving in the xy plane experiences a velocity dependent force $\vec{F} = k\left(v_y\hat{i} + v_x\hat{j}\right)$, where v_x and v_y are x and y components of its velocity $\vec{v}$. if $\vec{a}$ is the acceleration of the particle, then which of the following statements is true for the particle?
[Sep. 06, 2020 (II)]

Options:

A. quantity $\vec{v} \times \vec{a}$ is constant in time

B. $\vec{F}$ arises due to a magnetic field

C. kinetic energy of particle is constant in time

D. quantity $\vec{v} \cdot \vec{a}$ is constant in time

Answer: A

Solution:

Solution:
Given
$\vec{F} = k\left(v_y\hat{i} + v_x\hat{j}\right)$
$\therefore F_x = kv_y\hat{i}, F_y = kv_x\hat{j}$
$\frac{m\,dv_x}{dt} = kv_y \Rightarrow \frac{dv_x}{dt} = \frac{k}{m}v_y$
Similarly, $\frac{dv_y}{dt} = \frac{k}{m}v_x$
$\frac{dv_y}{dv_x} = \frac{v_x}{v_y} \Rightarrow \int v_y dv_y = \int v_x dv_x$
$v_y^2 = v_x^2 + C$
$v_y^2 - v_x^2 =$ constant
$\vec{v} \times \vec{a} = \left(v_x\hat{i} + v_y\hat{j}\right) \times \frac{k}{m}\left(v_y\hat{i} + v_x\hat{j}\right)$
$= \left(v_x^2\hat{k} - v_y^2\hat{k}\right)\frac{k}{m} = (v_x^2 - v_y^2)\frac{k}{m}\hat{k} =$ constant

----

Question109

A spaceship in space sweeps stationary interplanetary dust. As a result, its mass increases at a rate $\frac{dM(t)}{dt} = bv^2(t)$, where v(t) is its instantaneous velocity. The instantaneous acceleration of the satellite is :

[Sep. 05, 2020 (II)]

Options:

A. $-bv^3(t)$

B. $-\frac{bv^3}{M(t)}$

C. $-\frac{2bv^3}{M(t)}$

D. $-\frac{bv^3}{2M(t)}$

Answer: B

Solution:

Solution:
From the Newton's second law,
$F = \frac{dp}{dt} = \frac{d(mv)}{dt} = v\left(\frac{dm}{dt}\right)$ ......(i)
We have given, $\frac{dM(t)}{dt} = bv^2(t)$ .....(ii)
Thrust on the satellite,
$F = -v\left(\frac{dm}{dt}\right) = -v(bv^2) = -bv^3$[Using (i) and (ii)]
$\Rightarrow F = M(t)a = -bv^3 \Rightarrow a = \frac{-bv^3}{M(t)}$

Question110

A small ball of mass m is thrown upward with velocity u from the ground. The ball experiences a resistive force mkv^2 where v is its speed. The maximum height attained by the ball is:
[Sep. 04, 2020 (II)]

Options:

A. $\frac{1}{2k}\tan^{-1}\frac{ku^2}{g}$

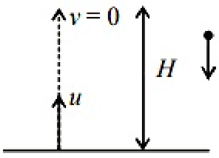
B. $\frac{1}{k}\ln\left(1+\frac{ku^2}{2g}\right)$

C. $\frac{1}{k}\tan^{-1}\frac{ku^2}{2g}$

D. $\frac{1}{2k}\ln\left(1+\frac{ku^2}{g}\right)$

Answer: D

Solution:



$(g + kv^2) = a$ (acceleration)

$\vec{F} = mkv^2 - mg$ ($\because mg$ and mkv^2 act opposite to each other)

$\vec{a} = \frac{\vec{F}}{m} = -[kv^2 + g]$

$\Rightarrow v \cdot \frac{dv}{dh} = -[kv^2 + g] \left(\because a = v\frac{dv}{dh}\right)$

$\Rightarrow \int_u^0 \frac{v \cdot dv}{kv^2 + g} = \int_0^h dh$

$\Rightarrow \frac{1}{2k} \ln[kv^2 + g]_u^0 = -h$

$\Rightarrow \frac{1}{2k} \ln\left[1 + \frac{ku^2}{g}\right] = h$

Question111

An insect is at the bottom of a hemispherical ditch of radius 1 m. It crawls up the ditch but starts slipping after it is at height h from the bottom. If the coefficient of friction between the ground and the insect is 0.75, then h is : ($g = 10\ ms^{-2}$)
[Sep. 06, 2020 (I)]

Options:

A. 0.20 m

B. 0.45 m

C. 0.60 m

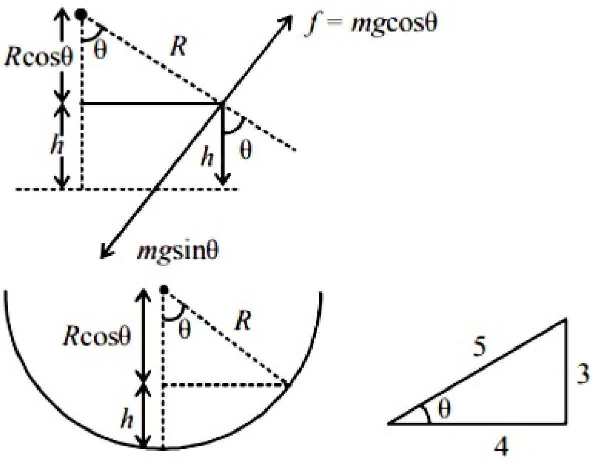
D. 0.80 m

Answer: A

Solution:

Solution:
For balancing, $mg\sin\theta = f = mu\, m\, g\cos\theta$

$\Rightarrow \tan\theta = \mu = \frac{3}{4} = 0.75$



$h = R - R\cos\theta = R - R\left(\frac{4}{5}\right) = \frac{R}{5}$
$\therefore h = R5 = 0.2m$ [$\because$ radius, $R = 1m$]

Question112

A block starts moving up an inclined plane of inclination 30° with an initial velocity of v_0. It comes back to itsinitial position with velocity $\frac{v_0}{2}$. The value of the coefficient of kinetic friction between the block and theinclined plane is close to $\frac{I}{1000}$. The nearest integer to I is _______.
[NA Sep. 03, 2020 (II)]

Answer: 346

Solution:

Solution:
Acceleration of block while moving up an inclined plane,
$a_1 = g\sin\theta + \mu g\cos\theta$
$\Rightarrow a_1 = g\sin 30° + \mu g\cos 30°$
$= \frac{g}{2} + \frac{\mu g\sqrt{3}}{2}$ .....(i) ($\because \theta = 30°$)
Using $v^2 - u^2 = 2a(s)$
$\Rightarrow {v_0}^2 - 0^2 = 2a_1(s)$ ($\because u = 0$)
$\Rightarrow {v_0}^2 - 2a_1(s) = 0$
$\Rightarrow s = \frac{{v_0}^2}{a_1}$ ....(ii)
Acceleration while moving down an inclined plane
$a_2 = g\sin\theta - \mu g\cos\theta$
$\Rightarrow a_2 = g\sin 30° - \mu g\cos 30°$
$\Rightarrow a_2 = \frac{g}{2} - \frac{\mu\sqrt{3}}{2}g$ ....(iii)
Using again $v^2 - u^2 = 2as$ for downward motion
$\Rightarrow \left(\frac{v_0}{2}\right)^2 = 2a_2(s) \Rightarrow s = \frac{{v_0}^2}{4a_2}$ ....(iv)
Equating equation (ii) and (iv)
$\frac{{v_0}^2}{a_1} = \frac{{v_0}^2}{4a_2} \Rightarrow a_1 = 4a_2$
$\Rightarrow \frac{g}{2} + \frac{\mu g\sqrt{3}}{2} = 4\left(\frac{g}{2} - \frac{\mu\sqrt{3}}{2}\right)$
$\Rightarrow 5 + 5\sqrt{3}\mu = 4(5 - 5\sqrt{3}\mu)$ (Substituting, $g = 10m/s^2$)
$\Rightarrow 5 + 5\sqrt{3}\mu = 20 - 20\sqrt{3}\mu \Rightarrow 25\sqrt{3}\mu = 15$
$\Rightarrow \mu = \frac{\sqrt{3}}{5} = 0.346 = \frac{346}{1000}$
So, $\frac{I}{1000} = \frac{346}{1000}$

Question113

A particle of mass m is moving in a straight line with momentum p.

Starting at time t = 0, a force F = kt acts in the same direction on the moving particle during time interval T so that its momentum changes from p to 3p. Here k is a constant. The value of T is :
[11 Jan. 2019 II]

Options:

A. $2\sqrt{\frac{k}{p}}$

B. $2\sqrt{\frac{p}{k}}$

C. $\sqrt{\frac{2k}{p}}$

D. $\sqrt{\frac{2p}{k}}$

Answer: B

Solution:

Solution:
From Newton's second law
$\frac{dp}{dt} = F = kt$
Integrating both sides we get,
$\int_p^{3p} dp = \int_0^T kt\,dt \Rightarrow [p]_p^{3p} = k\left[\frac{t^2}{2}\right]_0^T$
$\Rightarrow 2p = \frac{kT^2}{2} \Rightarrow T = 2\sqrt{\frac{p}{k}}$

Question114

A mass of 10 kg is suspended vertically by a rope from the roof. When a horizontal force is applied on the rope at some point, the rope deviated at an angle of 45°at the roof point. If the suspended mass is at equilibrium, the magnitude of the force applied is ($g = 10\ ms^{-2}$)
[9 Jan. 2019 II]

Options:

A. 200 N

B. 140 N

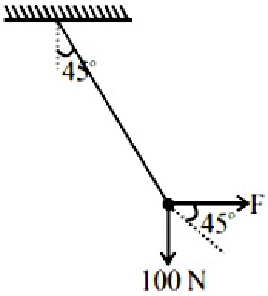
C. 70 N

D. 100 N

Answer: D

Solution:

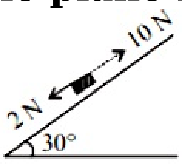
Solution:



At equilibrium,
$\tan 45° = \frac{mg}{F} = \frac{100}{F}$
$\therefore F = 100N$

Question115

A block kept on a rough inclined plane, as shown in the figure, remains at rest upto a maximum force 2 N down the inclined plane. The maximum external force up the inclined plane that does not move the block is 10 N. The coefficient of static friction between the block and the plane is : [Take g = 10 m/s^2]



[12 Jan. 2019 II]

Options:

A. $\frac{\sqrt{3}}{2}$

B. $\frac{\sqrt{3}}{4}$

C. $\frac{1}{2}$

D. $\frac{2}{3}$

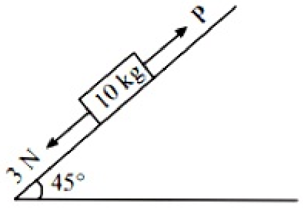
Answer: A

Solution:

Solution:
From figure, $2 + mg \sin 30° = \mu mg \cos 30°$ and $10 = mg \sin 30° + \mu mg \cos 30°$
$= 2\mu mg \cos 30° - 2$
$\Rightarrow 6 = \mu mg \cos 30°$ and
$4 = mg \cos 30°$
By dividing above two
$\Rightarrow \frac{3}{2} = \mu \times \sqrt{3}$
$\therefore$ Coefficient of friction, $\mu = \frac{\sqrt{3}}{2}$

Question116

A block of mass 10 kg is kept on a rough inclined plane as shown in the figure. A force of 3 N is applied on the block. The coefficient of static friction between the plane and the block is 0.6. What should be the minimum value of force P, such that the block does not move downward? (take g = 10 ms^{-2})



[9 Jan. 2019 I]

Options:

A. 32 N

B. 18 N

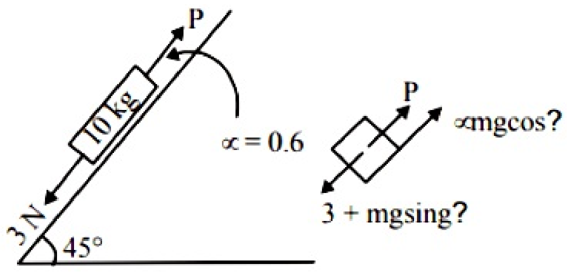
C. 23 N

D. 25 N

Answer: A

Solution:

Solution:



$mg\sin 45° = \frac{100}{\sqrt{2}} = 50\sqrt{2}$

$[\because m = 10kg,\ g = 9.8ms^{-2}]$

$\mu mg\cos\theta = 0.6 \times mg \times \frac{1}{\sqrt{2}} = 0.6'50\sqrt{2}$

$3 + mg\sin\theta = P + \mu mg\cos\theta$

$3 + 50\sqrt{2} = P + 30\sqrt{2}$

$\therefore P = 31.28 = 32N$

Question117

A ball is thrown upward with an initial velocity V_0 from the surface of the earth. The motion of the ball is affected by a drag force equal to $m\gamma v^2$ (where m is mass of the ball, v is its instantaneous velocity and γ is a constant). Time taken by the ball to rise to its zenith is:
[10 April 2019 I]

Options:

A. $\frac{1}{\sqrt{\gamma g}}\tan^{-1}\left(\sqrt{\frac{\gamma}{g}}V_0\right)$

B. $\frac{1}{\sqrt{\gamma g}}\sin^{-1}\left(\sqrt{\frac{\gamma}{g}}V_0\right)$

C. $\frac{1}{\sqrt{\gamma g}}\ln\left(1+\sqrt{\frac{\gamma}{g}}V_0\right)$

D. $\frac{1}{\sqrt{2\gamma g}}\tan^{-1}\left(\sqrt{\frac{2\gamma}{g}}V_0\right)$

Answer: A

Solution:

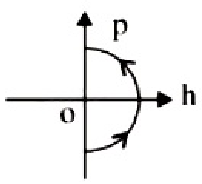
Solution:
Net acceleration
$\frac{dv}{dt} = a = -(g + \gamma v^2)$
Let time t required to rise to its zenith (v = 0) so,
$\int_{v_0}^{0} \frac{-dv}{g + \gamma v^2} = \int_0^t dt$ [for H_{max}, v = 0]
$\therefore t = \frac{1}{\sqrt{\gamma g}}\tan^{-1}\left(\frac{\sqrt{\gamma}v_0}{\sqrt{g}}\right)$

Question118

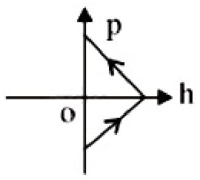
A ball is thrown vertically up (taken as + z-axis) from the ground. The correct momentum-height (p-h) diagram is:
[9 April 2019 I]

Options:

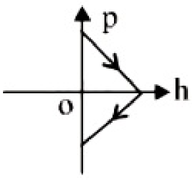
A.



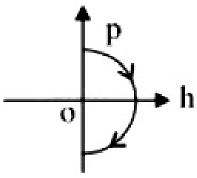
B.



C.



D.



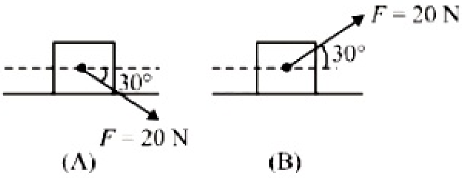
Answer: 0

Solution:

Solution:
$v^2 = u^2 - 2gh$
or $v = \sqrt{u^2 - 2gh}$
Momentum, $P = mv = m\sqrt{u^2 - 2gh}$
At $h = 0$, $P = mu$ and at $h = \frac{u^2}{f}$, $P = 0$
upward direction is positive and downward direction is negative.

Question119

A block of mass 5kg is (i) pushed in case (A) and (ii) pulled in case (B), by a force $F = 20N$, making an angle of 30° with the horizontal, as shown in the figures. The coefficient of friction between the block and floor is $\mu = 0.2$. The difference between the accelerations of the block, in case(B) and case (A) will be : ($g = 10ms^{-2}$)



[12 April 2019 II]

Options:

A. 0.4 ms^{-2}

B. 3.2 ms^{-2}

C. 0.8 ms^{-2}

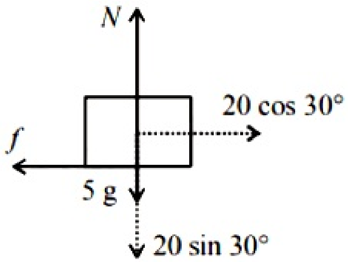
D. 0 ms^{-2}

Answer: C

Solution:

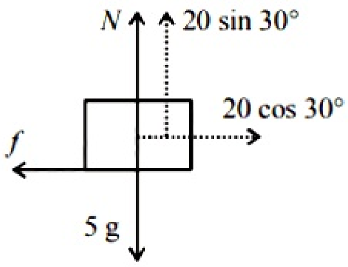
A : N $= 5g + 20\sin 30°$

$= 50 + 20 \times \frac{1}{2} = 60N$



Accelaration, $a_1 = \frac{F - f}{m} = \frac{20\cos 30° - \mu N}{5}$

$= \left[\frac{20 \times \frac{\sqrt{3}}{2} - 0.2 \times 60}{5}\right] = 1.06 m / s^2$



B : N $= 5g - 20\sin 30°$

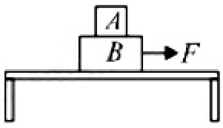
$= 50 - 20 \times \frac{1}{2} = 40N$

$a_2 = \frac{F - f}{m} = \left[\frac{20\cos 30° - 0.2 \times 40}{5}\right] = 1.86 m / s^2$

Now $a_2 - a_1 = 1.86 - 1.06 = 0.8 m / s^2$

Question120

Two blocks A and B masses $m_A = 1$ kg and $m_B = 3$ kg are kept on the table as shown in figure. The coefficient of friction between A and B is 0.2 and between B and the surface of the table is also 0.2. The maximum force F that can be applied on B horizontally, so that the block A does not slide over the block B is : [Take g = 10 m/s^2]



[10 April 2019 II]

Options:

A. 8 N

B. 16 N

C. 40 N

D. 12 N

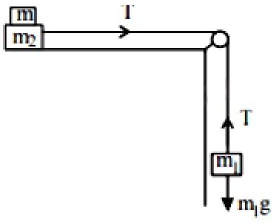
Answer: B

Solution:

Taking (A + B) as system
$F - mu(M + m)g$
$= (M + m)a$
$\Rightarrow a = \frac{F - \mu(M + m)g}{(M + m)}$
$a = \frac{F - (0.2)4 \times 10}{4} = \left(\frac{F - 8}{4}\right)$ ....(i)
But, $a_{max} = \mu g = 0.2 \times 10 = 2$
$\therefore \frac{F - 8}{4} = 2$
$\Rightarrow F = 16N$

Question121

Two masses $m_1 = 5kg$ and $m_2 = 10kg$, connected by an inextensible string over a frictionless pulley, are moving as shown in the figure. The coefficient of friction of horizontal surface is 0.15 . The minimum weight m that should be put on top of m_2 to stop the motion is:



[2018]

Options:

A. 18.3 kg

B. 27.3 kg

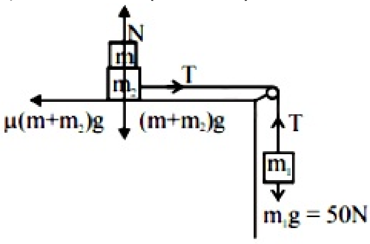
C. 43.3 kg

D. 10.3 kg

Answer: B

Solution:

Solution:
Given : $m_1 = 5kg$; $m_2 = 10kg$; $\mu = 0.15$
F BD for m_1, $m_1 g - T = m_1 a$
$\Rightarrow 50 - T = 5 \times a$
and, $T - 0.15(m + 10)g = (10 + m)a$
For rest $a = 0$
or, $50 = 0.15(m + 10)10$



$\Rightarrow 5 = \frac{3}{20}(m + 10)$
$\frac{100}{3} = m + 10 \therefore m = 23.3kg$; close to option(b)

Question122

A given object takes n times more time to slide down a 45° rough inclined plane as it takes to slide down a perfectly smooth 45° incline. The coefficient of kinetic friction between the object and the incline is : [Online April 15, 2018]

Options:

A. $\sqrt{1-\frac{1}{n^2}}$

B. $1-\frac{1}{n^2}$

C. $\frac{1}{2-n^2}$

D. $\sqrt{\frac{1}{1-n^2}}$

Answer: B

Solution:

Solution:
The coefficients of kinetic friction between the object and the incline

$\mu = \tan\theta\left(1-\frac{1}{n^2}\right) \Rightarrow \mu = 1-\frac{1}{n^2} (\because \theta = 45°)$

Question123

A body of mass 2kg slides down with an acceleration of $3m/s^2$ on a rough inclined plane having a slope of 30°.
The external force required to take the same body up the plane with the same acceleration will be: ($g = 10m/s^2$)
[Online April 15, 2018]

Options:

A. 4N

B. 14N

C. 6N

D. 20N

Answer: D

Solution:

Equation of motion when the mass slides down
$M g \sin\theta - f = M a$
$\Rightarrow 10 - f = 6(M = 2kg, a = 3m/s^2, \theta = 30°$. given)
$\therefore f = 4N$
Equation of motion when the block is pushed up
Let the external force required to take the block up the plane with same acceleration be F
$F - M g \sin\theta - f = M a$
$\Rightarrow F - 10 - 4 = 6$
$F = 20N$

Question124

A disc rotates about its axis of symmetry in a horizontal plane at a steady rate of 3.5 revolutions per second. A coin placed at a distance of 1.25cm from the axis of rotation remains at rest on the disc. The coefficient of friction between the coin and the disc is ($g = 10m/s^2$) [Online April 15, 2018]

Options:

A. 0.5

B. 0.7

C. 0.3

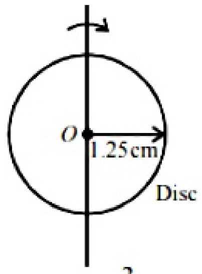
D. 0.6

Answer: D

Solution:

Solution:

Using, $\mu mg = \frac{mv^2}{r} = mr\omega^2$
$\omega = 2\pi n = 2\pi \times 3.5 = 7\pi rad$ / sec
Radius, $r = 1.25cm = 1.25 \times 10^{-2}m$
Coefficient of friction, $\mu = ?$
$\mu mg = \frac{m(r\omega)^2}{r} (\because v = r\omega)$

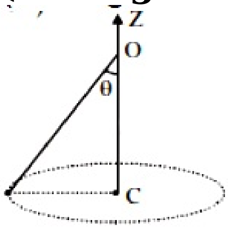


$\mu mg = mr\omega^2$

$$\Rightarrow \mu = \frac{r\omega^2}{g} = \frac{1.25 \times 10^{-2} \times \left(7 \times \frac{22}{7}\right)^2}{10}$$
$$= \frac{1.25 \times 10^{-2} \times 22^2}{10} = 0.6$$

Question125

A conical pendulum of length 1 m makes an angle θ = 45° w.r.t. Z-axis and moves in a circle in the XY plane. The radius of the circle is 0.4 m and its centre is vertically below O. The speed of the pendulum, in its circular path, will be :
(Take $g = 10\ ms^{-2}$)



[Online April 9, 2017]

Options:

A. 0.4 m/s

B. 4 m/s

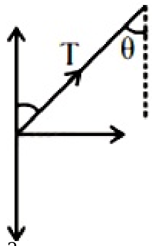
C. 0.2 m/s

D. 2 m/s

Answer: D

Solution:

Solution:
Given, $\theta = 45°$, $r = 0.4m$, $g = 10m / s^2$
$\sin\theta = \frac{mv^2}{r}$ ......(i)
$T\ \cos\theta = mg$ ....(ii)
From equation(i) & (ii) we have,
$\tan\theta = \frac{v^2}{rg}$



$v^2 = rg \because \theta = 45°$
Hence, speed of the pendulum in its circular path,
$v = \sqrt{rg} = \sqrt{0.4 \times 10} = 2m / s$

Question126

A particle of mass m is acted upon by a force F given by the empirical law $F = \frac{R}{t^2}v(t)$. If this law is to be tested experimentally by observing the motion starting from rest, the best way is to plot :
[Online April 10, 2016]

Options:

A. $\log v(t)$ against $\frac{1}{t}$

B. $v(t)$ against t^2

C. $\log v(t)$ against $\frac{1}{t^2}$

D. $\log v(t)$ against t

Answer: A

Solution:

Solution:

From $F = \frac{R}{t^2}v(t) \Rightarrow m\frac{dv}{dt} = \frac{R}{t^2}v(t)$

Integrating both sides $\int \frac{dv}{dt} = \int \frac{Rdt}{mt^2}$

In $v = -\frac{R}{mt}$

$\therefore \ln v \propto \frac{1}{t}$

Question127

A rocket is fired vertically from the earth with an acceleration of 2g, where g is the gravitational acceleration. On an inclined plane inside the rocket, making an angle θ with the horizontal, a point object of mass m is kept. The minimum coefficient of friction μ_{min} between the mass and the inclined surface such that the mass does not move is: [Online April 9, 2016]

Options:

A. $\tan 2\theta$

B. $\tan\theta$

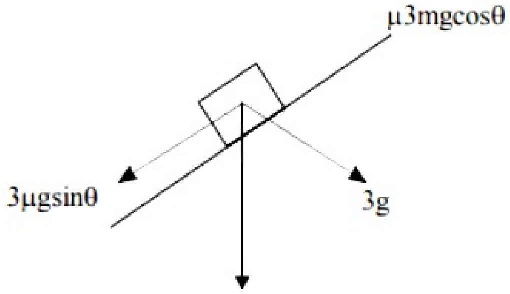
C. $3\tan\theta$

D. $2\tan\theta$

Answer: B

Solution:

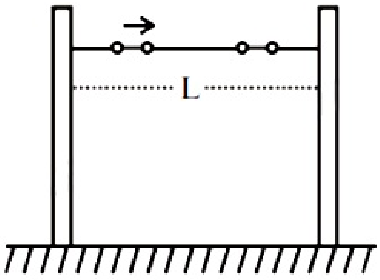
Solution:
Let μ be the minimum coefficient of friction



At equilibrium, mass does not move so,
$3mg\sin\theta = \mu 3mg\cos\theta$
$\therefore \mu_{min} = \tan\theta$

Question128

A large number (n) of identical beads, each of mass m and radius r are strung on a thin smooth rigid horizontal rod of length L (L >> r) and are at rest at random positions. The rod is mounted between two rigid supports (see figure). If one of the beads is now given a speed v, the average force experienced by each support after a long time is (assume all collisions are elastic):



[Online April 11, 2015]

Options:

A. $\frac{mv^2}{2(L-nr)}$

B. $\frac{mv^2}{L-2nr}$

C. $\frac{mv^2}{L-nr}$

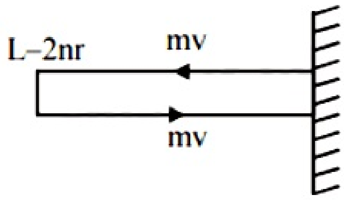
D. zero

Answer: B

Solution:

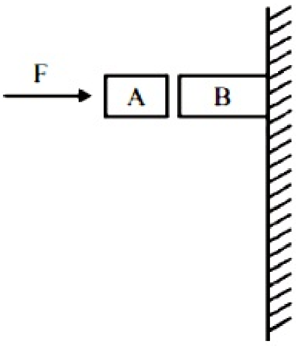
Solution:
Space between the supports for motion of beads is $L-2nr$
Average force experienced by each support,

$$F = \frac{2mV}{\frac{2(L-2nr)}{V}} = \frac{mV^2}{L-2nr}$$



Question129

Given in the figure are two blocks A and B of weight 20 N and 100 N, respectively. These are being pressed against a wall by a force F as shown. If the coefficient of friction between the blocks is 0.1 and between block B and the wall is 0.15, the frictional force applied by the wall on block B is:



[2015]

Options:

A. 120 N

B. 150 N

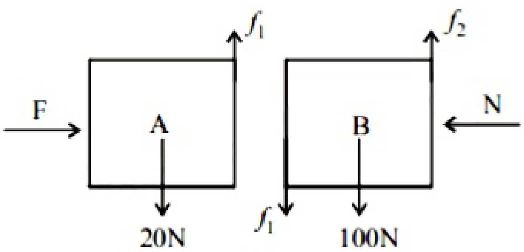
C. 100 N

D. 80 N

Answer: A

Solution:

Solution:

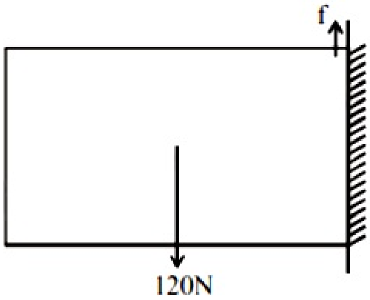


Assuming both the blocks are stationary

N = F

$f_1 = 20N$

$f_2 = 100 + 20 = 120N$



Considering the two blocks as one system and due to equilibrium $f = 120N$

Question130

A block of mass m = 10 kg rests on a horizontal table. The coefficient of friction between the block and the table is 0.05. When hit by a bullet of mass 50 g moving with speed n, that gets embedded in it, the block moves and comes to stop after moving a distance of 2 m on the table. If a freely falling object were to acquire speed $\frac{v}{10}$ after being dropped from height H, then neglecting energy losses and taking g= 10 ms^{-2}, the value of H is close to:
[Online April 10, 2015]

Options:

A. 0.05 km

B. 0.02 km

C. 0.03 km

D. 0.04 km

Answer: D

Solution:

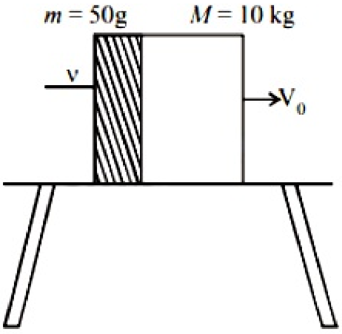
Solution:

$f = \mu(M + m)g$

$a = \frac{f}{M + m} = \frac{\mu(M + m)g}{(M + m)} = \mu g$

$= 0.05 \times 10 = 0.5 ms^{-2}$

$V_0 = \frac{\text{Initial momentum}}{(M + m)} = \frac{0.05V}{10.05}$



$v^2 - u^2 = 2as$

$0 - u^2 = 2as$

$u^2 = 2as$

$$\left(\frac{0.05v}{10.05}\right)^2 = 2 \times 0.5 \times 2$$

Solving we get $v = 201\sqrt{2}$

Object falling from height H .

$$\frac{V}{10} = \sqrt{2gH}$$

$$\frac{201\sqrt{2}}{10} = \sqrt{2 \times 10 \times H}$$

$H = 40m = 0.04km$

Question131

A body of mass 5kg under the action of constant force $\vec{F} = F_x\hat{i} + F_y\hat{j}$ has velocity at t = 0s as $\vec{v} = (6\hat{i} - 2\hat{j})\,m/s$ and at t = 10s as $\vec{v} = +6\hat{j}\,m/s$. The force $\vec{F}$ is:

[Online April 11, 2014]

Options:

A. $(-3\hat{j} + 4\hat{j})N$

B. $\left(-\frac{3}{5}\hat{i} + \frac{4}{5}\hat{j}\right)N$

C. $(3\hat{j} - 4\hat{j})N$

D. $\left(\frac{3}{5}\hat{i} - \frac{4}{5}\hat{j}\right)N$

Answer: A

Solution:

Solution:

From question,

Mass of body, $m = 5kg$

Velocity at $t = 0$,

$u = (6\hat{i} - 2\hat{j})m/s$

Velocity at $t = 10s$

$v = +6\hat{j}\,m/s$

Force, $F = ?$

Acceleration, $a = \frac{v-u}{t}$

$$= \frac{6\hat{j} - (6\hat{i} - 2\hat{j})}{10} = \frac{-3\hat{i} + 4\hat{j}}{5} m/s^2$$

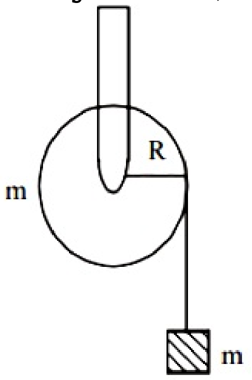
Force, $F = ma$

$$= 5 \times \frac{(-3\hat{i} + 4\hat{j})}{5} = (-3\hat{i} + 4\hat{j})N$$

Question132

A mass 'm' is supported by a massless string wound around a uniform hollow cylinder of mass m and radius R. If the string does not slip on

the cylinder, with what acceleration will the mass fall or release?



[2014]

Options:

A. $\frac{2g}{3}$

B. $\frac{g}{2}$

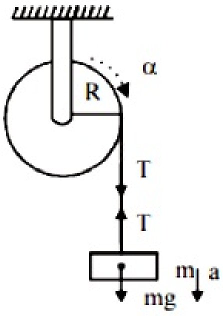
C. $\frac{5g}{6}$

D. g

Answer: B

Solution:

Solution:
From figure,



Acceleration $a = R\alpha$ ......(i)
and $mg - T = ma$ ....(ii)
From equation (i) and (ii)
$T \times R = mR^2\alpha = mR^2\left(\frac{a}{R}\right)$
or $T = ma$
$\Rightarrow mg - ma = ma$
$\Rightarrow a = \frac{g}{2}$

Question133

A block of mass m is placed on a surface with a vertical cross section given by $y = \frac{x^3}{6}$. If the coefficient of friction is 0.5, the maximum height above the ground at which the block can be placed without slipping is: [2014]

Options:

A. $\frac{1}{6}$m

B. $\frac{2}{3}$m

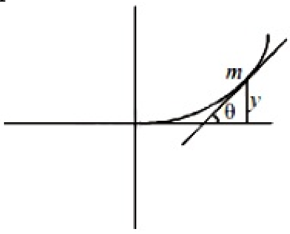
C. $\frac{1}{3}$m

D. $\frac{1}{2}$m

Answer: A

Solution:

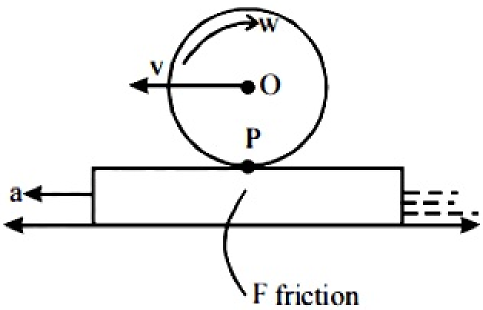
Solution:
At limiting equilibrium,
$\mu = \tan\theta$



$\tan\theta = \mu = \frac{dy}{dx} = \frac{x^2}{2}$ (from question)
∵ Coefficient of friction $\mu = 0.5$
$\therefore 0.5 = \frac{x^2}{2}$
$\Rightarrow x = \pm 1$
Now, $y = \frac{x^3}{6} = \frac{1}{6}$m

Question134

Consider a cylinder of mass M resting on a rough horizontal rug that is pulled out from under it with acceleration 'a' perpendicular to the axis of the cylinder. What is F friction at point P? It is assumed that the cylinder does not slip.



[Online April 19, 2014]

Options:

A. Mg

B. Ma

C. $\frac{Ma}{2}$

D. $\frac{Ma}{3}$

Answer: D

Solution:

Solution:
Force of friction at point P ,

$F_{friction} = \frac{1}{3} M a \sin\theta$

$= \frac{1}{3} M a \sin 90° \left[\text{ here } \theta = 90° \right]$

$= \frac{M a}{3}$

Question135

A heavy box is to dragged along a rough horizontal floor. To do so, person A pushes it at an angle 30° from the horizontal and requires a minimum force F_A, while person B pulls the box at an angle 60° from the horizontal and needs minimumforce F_B . If the coefficient of friction between the box and the floor is $\frac{\sqrt{3}}{5}$, the ratio $\frac{F_A}{F_B}$ is
[Online April 19, 2014]

Options:

A. $\sqrt{3}$

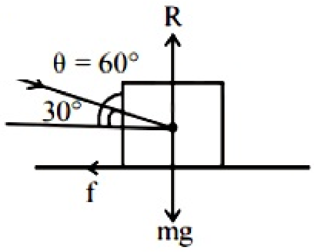
B. $\frac{5}{\sqrt{3}}$

C. $\sqrt{\frac{3}{2}}$

D. $\frac{2}{\sqrt{3}}$

Answer: D

Solution:



$F_A = \frac{\mu mg}{\sin\theta - \mu\cos\theta}$
Similarly,

$F_B = \frac{\mu mg}{\sin\theta + \mu\cos\theta}$

$\therefore \frac{F_A}{F_B} = \frac{\frac{\mu mg}{\sin\theta - \mu\cos\theta}}{\frac{\mu mg}{\sin\theta + \mu\cos\theta}}$

$= \frac{\frac{\mu mg}{\sin 60° - \frac{\sqrt{3}}{5}\cos 60°}}{\frac{\mu mg}{\sin 30° + \frac{\sqrt{3}}{5}\cos 30°}} \left[\mu = \frac{\sqrt{3}}{5} \text{ given}\right]$

$= \frac{\sin 30° + \frac{\sqrt{3}}{5}}{\sin 60° - \frac{\sqrt{3}}{5}\cos 60°}$

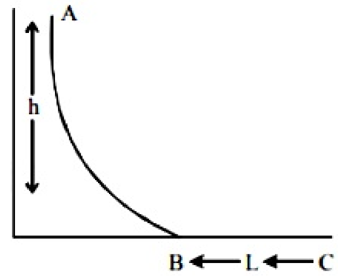
$= \frac{\frac{1}{2} + \frac{\sqrt{3}}{5} \times \frac{\sqrt{3}}{2}}{\frac{\sqrt{3}}{2} - \frac{\sqrt{3}}{5} \times \frac{1}{2}}$

$= \frac{\frac{1}{2}\left(1 + \frac{3}{5}\right)}{\frac{\sqrt{3}}{5}\left(1 - \frac{1}{5}\right)} = \frac{\frac{1}{2} \times \frac{8}{5}}{\frac{\sqrt{3} \times 4}{10}}$

$= \frac{\frac{8}{10}}{\frac{\sqrt{3} \times 4}{10}} = \frac{8}{\sqrt{3} \times 4} = \frac{2}{\sqrt{3}}$

Question136

A small ball of mass m starts at a point A with speed v_o and moves along a frictionless track AB as shown. The track BC has coefficient of friction μ. The ball comes to stop at C after travelling a distance L which is:



[Online April 11, 2014]

Options:

A. $\frac{2h}{\mu} + \frac{v_o^2}{2\mu g}$

B. $\frac{h}{\mu} + \frac{v_o^2}{2\mu g}$

C. $\frac{h}{2\mu} + \frac{v_o^2}{\mu g}$

D. $\frac{h}{2\mu} + \frac{v_o^2}{2\mu g}$

Answer: B

Solution:

Solution:
Initial speed at point A, $u = v_0$
Speed at point mathrm B, $v = ?$
$v^2 - u^2 = 2gh$
$v^2 = v_0^{\ 2} + 2gh$
Let ball travels distance ' S ' before coming to rest
$S = \frac{v^2}{2\mu g} = \frac{v_0^{\ 2} + 2gh}{2\mu g}$
$= \frac{v_0^{\ 2}}{2\mu g} + \frac{2gh}{2\mu g} = \frac{h}{\mu} + \frac{v_0^{\ 2}}{2\mu g}$

Question137

A block A of mass 4 kg is placed on another block B of mass 5 kg, and the block B rests on a smooth horizontal table. If the minimum force that can be applied on A so that both the blocks move together is 12 N, the maximum force that can be applied to B for the blocks to move together will be:
[Online April 9, 2014]

Options:

A. 30 N

B. 25 N

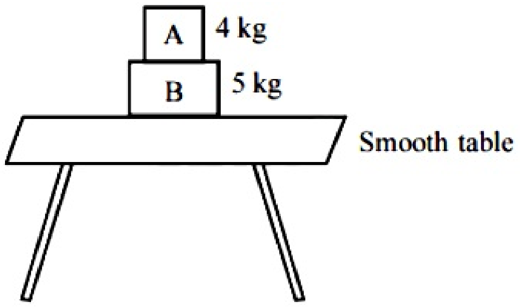
C. 27 N

D. 48 N

Answer: C

Solution:

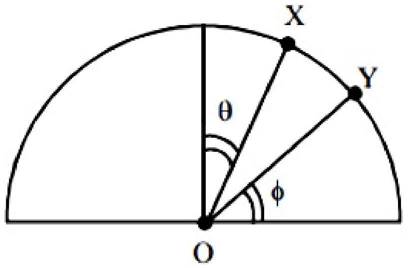
Solution:
Minimum force on A
= frictional force between the surfaces
$= 12N$



Therefore maximum acceleration
$a_{max} = \frac{12N}{4kg} = 3m / s^2$
Hence maximum force,
$F_{max} =$ total mass $\times a_{max}$
$= 9 \times 3 = 27N$

Question138

A particle is released on a vertical smooth semicircular track from point X so that OX makes angle θ from the vertical (see figure). The normal reaction of the track on the particle vanishes at point Y where OY makes angle ϕ with the horizontal. Then:



[Online April 19, 2014]

Options:

A. $\sin\phi = \cos\phi$

B. $\sin\phi = \frac{1}{2}\cos\theta$

C. $\sin\phi = \frac{2}{3}\cos\theta$

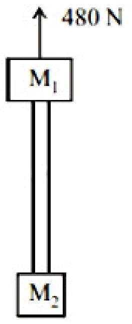
D. $\sin\phi = \frac{3}{4}\cos\theta$

Answer: C

Solution:

Question139

Two blocks of mass M_1 = 20 kg and M_2 = 12 kg are connected by a metal rod of mass 8 kg. The system is pulled vertically up by applying a force of 480 N as shown. The tension at the mid-point of the rod is :



[Online April 22, 2013]

Options:

A. 144 N

B. 96 N

C. 240 N

D. 192 N

Answer: D

Solution:

Acceleration produced in upward direction $a = \frac{F}{M_1 + M_2 + \text{Mass of metal rod}}$

$= \frac{480}{20 + 12 + 8} = 12 ms^{-2}$

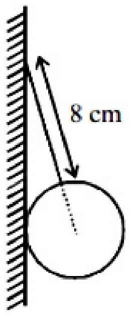
Tension at the mid point

$T = \left(M_2 + \frac{\text{Mass of rod}}{2}\right) a$

$= (12 + 4) \times 12 = 192 N$

Question140

A uniform sphere of weight W and radius 5 cm is being held by a string as shown in the figure. The tension in the string will be :



[Online April 9, 2013]

Options:

A. $12\frac{W}{5}$

B. $5\frac{W}{12}$

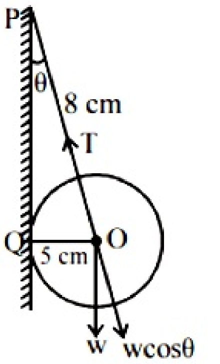
C. $13\frac{W}{5}$

D. $13\frac{W}{12}$

Answer: D

Solution:

Solution:



$PQ = \sqrt{OP^2 + OQ^2}$

$= \sqrt{13^2 + 5^2} = 12$

Tension in the string

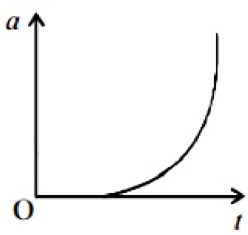
$T = w\cos\theta = \frac{13}{12}W$

Question141

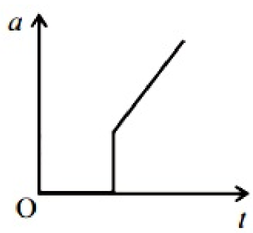
A block is placed on a rough horizontal plane. A time dependent horizontal force F = kt acts on the block, where k is a positive constant. The acceleration - time graph of the block is :
[Online April 25, 2013]

Options:

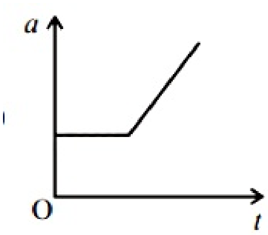
A.



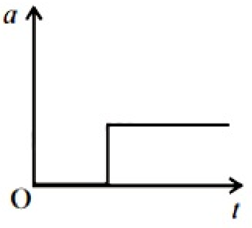
B.



C.



D.



Answer: B

Solution:

Solution:
Graph (b) correctly dipicts the acceleration-time graph of the block.

Question142

A body starts from rest on a long inclined plane of slope 45°. The coefficient of friction between the body and the plane varies as μ = 0.3 x, where x is distance travelled down the plane. The body will have maximum speed (for g = 10 m/s^2) when x =
[Online April 22, 2013]

Options:

A. 9.8 m

B. 27 m

C. 12 m

D. 3.33 m

Answer: D

Solution:

Solution:
When the body has maximum speed then
$\mu = 0.3x = \tan 45°$
$\therefore x = 3.33m$

Question143

A body of mass 'm' is tied to one end of a spring and whirled round in a horizontal plane with a constant angular velocity. The elongation in the spring is 1 cm. If the angular velocity is doubled, the elongation in the spring is 5 cm. The original length of the spring is :
[Online April 23, 2013]

Options:

A. 15 cm

B. 12 cm

C. 16 cm

D. 10 cm

Answer: A

Solution:

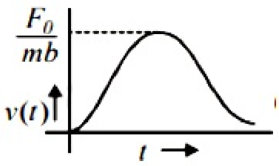
Solution:

Question144

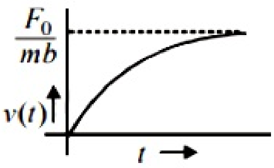
A particle of mass m is at rest at the origin at time t = 0. It is subjected to a force $F(t) = F_0 e^{-bt}$ in the x direction. Its speed v(t) is depicted by which of the following curves?
[2012]

Options:

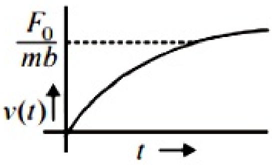
A.



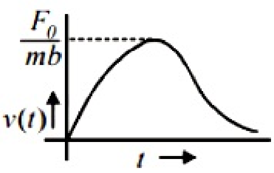
B.



C.



D.



Answer: C

Solution:

Solution:

Given that $F(t) = F_0 e^{-bt}$

$\Rightarrow m\frac{dv}{dt} = F_0 e^{-bt}$

$\frac{dv}{dt} = \frac{F_0}{m} e^{-bt}$

$\int_0^v dv = \frac{F_0}{m} \int_0^t e^{-bt} dt$

$v = \frac{F_0}{m}\left[\frac{e^{-bt}}{-b}\right]_0^t = \frac{F_0}{mb}[-(e^{-bt} - e^{-0})]$

$\Rightarrow v = \frac{F_0}{mb}[1 - e^{-bt}]$

Question145

This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.
Statement 1: If you push on a cart being pulled by a horse so that it does not move, the cart pushes you back with an equal and opposite force.
Statement 2: The cart does not move because the force described in statement 1 cancel each other.
[Online May 26, 2012]

Options:

A. Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation of Statement 1.

B. Statement 1 is false, Statement 2 is true.

C. Statement 1 is true, Statement 2 is false.

D. Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1.

Answer: A

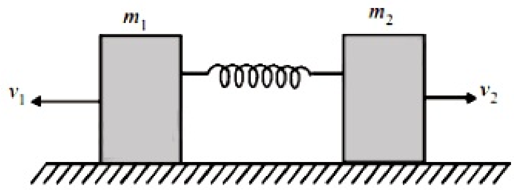
Solution:

Solution:
According to newton third law of motion i.e. every action is associated with equal and opposite reaction.

Question146

A spring is compressed between two blocks of masses m_1 and m_2 placed on a horizontal frictionless surface as shown in the figure. When the blocks are released, they have initial velocity of v_1 and v_2 as shown. The

blocks travel distances x_1 and x_2 respectively before coming to rest. The ratio $\left(\frac{x_1}{x_2}\right)$ is



[Online May 12, 2012]

Options:

A. $\frac{m_2}{m_1}$

B. $\frac{m_1}{m_2}$

C. $\sqrt{\frac{m_2}{m_1}}$

D. $\sqrt{\frac{m_1}{m_2}}$

Answer: A

Solution:

Solution:

Question147

A block of weight W rests on a horizontal floor with coefficient of static friction μ. It is desired to make the block move by applying minimum amount of force. The angle θ from the horizontal at which the force should be applied and magnitude of the force F are respectively.
[Online May 19, 2012]

Options:

A. $\theta = \tan^{-1}(\mu)$, $F = \frac{\mu W}{\sqrt{1+\mu^2}}$

B. $\theta = \tan^{-1}\left(\frac{1}{\mu}\right)$, $F = \frac{\mu W}{\sqrt{1+\mu^2}}$

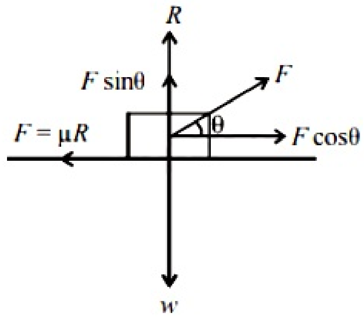
C. $\theta = 0$, $F = \mu W$

D. $\theta = \tan^{-1}\left(\frac{\mu}{1+\mu}\right)$, $F = \frac{\mu W}{1+\mu}$

Answer: A

Solution:

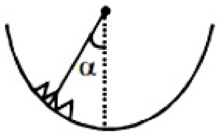
Solution:
Let the force F is applied at an angle θ with the horizontal.



For horizontal equilibrium,
$F \cos\theta = \mu R$ ....(i)
For vertical equilibrium,
$R + F \sin\theta = mg$
or, $R = mg - F \sin\theta$ ....(ii)
Substituting this value of R in eq. (i), we get
$F \cos\theta = \mu(mg - F \sin\theta)$
$= \mu mg - \mu F \sin\theta$
or, $F(\cos\theta + \mu \sin\theta) = \mu mg$
or, $F = \dfrac{\mu mg}{\cos\theta + \mu \sin\theta}$ ....(iii)
For F to be minimum, the denominator $(\cos\theta + \mu \sin\theta)$ should be maximum.
$\therefore \dfrac{d}{d\theta}(\cos\theta + \mu \sin\theta) = 0$
or, $-\sin\theta + \mu \cos\theta = 0$
or, $\tan\theta = \mu$
or, $\theta = \tan^{-1}(\mu)$
Then, $\sin\theta = \dfrac{\mu}{\sqrt{1 + \mu^2}}$ and
$\cos\theta = \dfrac{1}{\sqrt{1 + \mu^2}}$
Hence, $F_{min} = \dfrac{\mu w}{\dfrac{1}{\sqrt{1+\mu^2}} + \dfrac{\mu^2}{\sqrt{1+\mu^2}}} = \dfrac{\mu w}{\sqrt{1+\mu^2}}$

Question148

An insect crawls up a hemispherical surface very slowly. The coefficient of friction between the insect and the surface is 1/3. If the line joining the centre of the hemispherical surface to the insect makes an angle α with the vertical, the maximum possible value of α so that the insect does not slip is given by



[Online May 12, 2012]

Options:

A. $\cot \alpha = 3$

B. $\sec \alpha = 3$

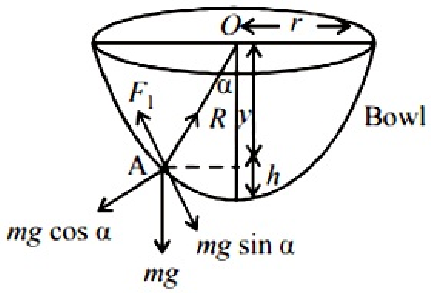
C. $\text{cosec } \alpha = 3$

D. $\cos \alpha = 3$

Answer: A

Solution:

Solution:



mgThe insect crawls up the bowl upto a certain height honly till the component of its weight along the bowl is balanced by limiting frictional force.
For limiting condition at point A
$R = mg\cos\alpha$ .....(i)
$F_1 = mg\sin\alpha$ ....(ii)
Dividing eq. (ii) by (i)
$\tan\alpha = \frac{1}{\cot\alpha} = \frac{F_1}{R} = \mu$[As $F_1 = \mu R$]
$\Rightarrow \tan\alpha = \mu = \frac{1}{3}\left[\because \mu = \frac{1}{3}\left(\text{ Given }\right)\right]$
$\therefore \cot\alpha = 3$

Question149

The minimum force required to start pushing a body up rough (frictional coefficient μ) inclined plane is F_1 while the minimum force needed to prevent it from sliding down is F_2. If the inclined plane makes an angle theta from the horizontal such that $\tan\theta = 2\mu$ then the ratio $\frac{F_1}{F_2}$ is
[2011 RS]

Options:

A. 1

B. 2

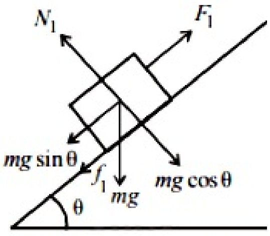
C. 3

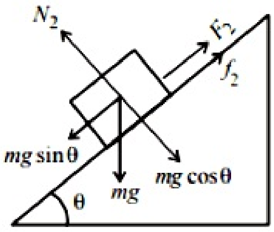
D. 4

Answer: C

Solution:

Solution:





When the body slides up the inclined plane, then
$mg\sin\theta + f_1 = F_1$
or, $F_1 = mg\sin\theta + \mu mg\cos\theta$
When the body slides down the inclined plane, then
$mg\sin\theta - f_2 = F_2$
or $F_2 = mg\sin\theta - \mu mg\cos\theta$
$\therefore \frac{F_1}{F_2} = \frac{\sin\theta + \mu\cos\theta}{\sin\theta - \mu\cos\theta}$
$\Rightarrow \frac{F_1}{F_2} = \frac{\tan\theta + \mu}{\tan\theta - \mu} = \frac{2\mu + \mu}{2\mu - \mu} = \frac{3\mu}{\mu} = 3$

Question150

If a spring of stiffness ' k ' is cut into parts ' A ' and ' B ' oflength $l_A : l_B = 2 : 3$, then the stiffness of spring ' A ' is given by [2011 RS]

Options:

A. $\frac{3k}{5}$

B. $\frac{2k}{5}$

C. k

D. $\frac{5k}{2}$

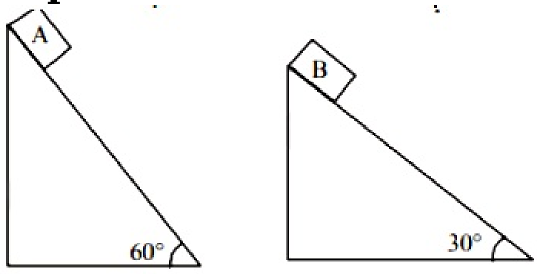
Answer: D

Solution:

Solution:
It is given $l_A : l_B = 2 : 3$
$l_A = \frac{2l}{5}, l_B = \left(\frac{3l}{5}\right)$
$\therefore$ We know that $k \propto \frac{1}{l}$
If initial spring constant is k, then
$kl = k_A l_A = k_B l_B$
$kl = k_A\left(\frac{2l}{5}\right)$
$k_A = \frac{5k}{2}$

Question151

Two fixed frictionless inclined planes making an angle 30° and 60° with the vertical are shown in the figure. Two blocks A and B are placed on the two planes. What is the relative vertical acceleration of A with respect to B ?



[2010]

Options:

A. $4.9 ms^{-2}$ in horizontal direction

B. $9.8 ms^{-2}$ in vertical direction

C. Zero

D. $4.9 ms^{-2}$ in vertical direction

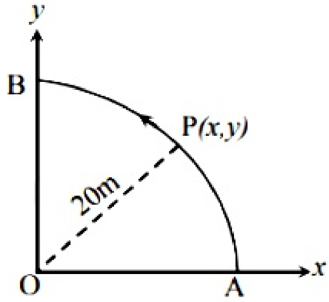
Answer: D

Solution:

Solution:
$mg \sin \theta = ma$
$\therefore a = g \sin \theta$
$\therefore$ Vertical component of acceleration $= g\sin^2\theta$
$\therefore$ Relative vertical acceleration of A with respect to B is $g(\sin^2 60 - \sin^2 30]$
$= g\left(\frac{3}{4} - \frac{1}{4}\right) = \frac{g}{2} = 4.9 m / s^2$
in vertical direction

Question152

A point P moves in counter-clockwise direction on a circular path as shown in the figure. The movement of 'P' is such that it sweeps out a length $s = t^3 + 5$, where s is in metres and t is in seconds. The radius of the path is 20 m. The acceleration of 'P' when t = 2 s is nearly.



[2010]

Options:

A. $13 m/s^2$

B. $12\ m/s^2$

C. $7.2\ ms^2$

D. $14 m/s^2$

Answer: D

Solution:

Solution:

$s = t^3 + 5$

$\Rightarrow$ velocity, $v = \frac{ds}{dt} = 3t^2$

Tangential acceleration $a_t = \frac{dv}{dt} = 6t$

Radial acceleration $a_c = \frac{v^2}{R} = \frac{9t^4}{R}$

At t = 2s, $a_t = 6 \times 2 = 12 m / s^2$

$a_c = \frac{9 \times 16}{20} = 7.2 m / s^2$

$\therefore$ Resultant acceleration

$= \sqrt{a_t^2 + a_c^2}$

$= \sqrt{(12)^2 + (7.2)^2} = \sqrt{144 + 51.84}$

$= \sqrt{195.84} = 14 m / s^2$

Question153

For a particle in uniform circular motion, the acceleration $\vec{a}$ at a point P(R, θ) on the circle of radius R is (Here θ is measured from the x -axis)
[2010]

Options:

A. $-\frac{v^2}{R}\cos\theta\,\hat{i} + \frac{v^2}{R}\sin\theta\,\hat{j}$

B. $-\frac{v^2}{R}\sin\theta\,\hat{i} + \frac{v^2}{R}\cos\theta\,\hat{j}$

C. $-\frac{v^2}{R}\cos\theta\,\hat{i} - \frac{v^2}{R}\sin\theta\,\hat{j}$

D. $\frac{v^2}{R}\hat{i} + \frac{v^2}{R}\hat{j}$

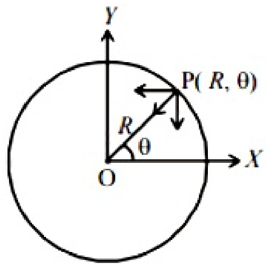
Answer: C

Solution:

Solution:

Clearly $\vec{a} = a_c \cos\theta(-\hat{i}) + a_c \sin\theta(-\hat{j})$

$= \frac{-v^2}{R}\cos\theta\,\hat{i} - \frac{v^2}{R}\sin\theta\,\hat{j}$



Question154

A block of mass m is connected to another block of mass M by a spring (massless) of spring constant k. The block are kept on a smooth horizontal plane. Initially the blocks are at rest and the spring is unstretched. Then a constant force F starts acting on the block of mass M to pull it. Find the force of the block of mass m.
[2007]

Options:

A. $\frac{MF}{(m+M)}$

B. $\frac{mF}{M}$

C. $\frac{(M+m)F}{m}$

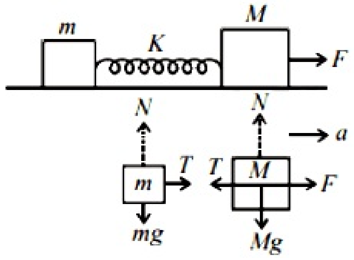
D. $\frac{mF}{(m+M)}$

Answer: D

Solution:

Solution:

Writing free body-diagrams for m & M



we get $T = ma$ and $F - T = Ma$

where T is force due to spring
$\Rightarrow F - ma = Ma$ or, $F = Ma + ma$
∴ Acceleration of the system
$a = \frac{F}{M + m}$
Now, force acting on the block of mass m is
$ma = m\left(\frac{F}{M + m}\right) = \frac{mF}{m + M}$
If a is the acceleration along the inclined plane, then

Question155

A ball of mass 0.2 kg is thrown vertically upwards by applying a force by hand. If the hand moves 0.2 m while applying the force and the ball goes upto 2 m height further, find the magnitude of the force. (Consider $g = 10\ m/s^2$).
[2006]

Options:

A. 4 N

B. 16 N

C. 20 N

D. 22 N

Answer: D

Solution:

Solution:
For the motion of ball, just after the throwing
$v = 0, s = 2m, a = -g = -10ms^{-2}$
$v^2 - u^2 = 2$ as for upward journey
$\Rightarrow -u^2 = 2(-10) \times 2 \Rightarrow u^2 = 40$
When the ball is in the hands of the thrower
$u = 0, v = \sqrt{40}ms^{-1}$
$s = 0.2m$
$v^2 - u^2 = 2as$
$\Rightarrow 40 - 0 = 2(a)0.2 \Rightarrow a = 100m / s^2$
$\therefore F = ma = 0.2 \times 100 = 20N$
$\Rightarrow N - mg = 20 \Rightarrow N = 20 + 2 = 22N$
Note $W_{hand} + W_{gravity} = \Delta K$
$\Rightarrow F(0.2) + (0.2)(10)(2.2) = 0 \Rightarrow F = 22N$

Question156

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 0.1s, the force of the blow exerted by the ball on the hand of the player is equal to
[2006]

Options:

A. 150 N

B. 3 N

C. 30 N

D. 300 N

Answer: C

Solution:

Solution:
Given, mass of cricket ball, $m = 150g = 0.15kg$
Initial velocity, $u = 20m / s$
Force,
$$F = \frac{m(v-u)}{t} = \frac{0.15(0-20)}{0.1} = 30N$$

Question157

A particle of mass 0.3 kg subject 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 ?
[2005]

Options:

A. 15 m/s^2

B. 3 m/s^2

C. 10 m/s^2

D. 5 m/s^2

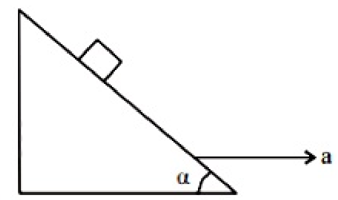
Answer: C

Solution:

Solution:
$Mass(m) = 0.3kg$
Force, $F = m . a = -kx$
$\Rightarrow ma = -15x$
$\Rightarrow 0.3a = -15x$
$$\Rightarrow a = -\frac{15}{0.3}x = \frac{-150}{3}x = -50x$$
$a = -50 \times 0.2 = 10m / s^2$

Question158

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



[2005]

Options:

A. g cosec α

B. g / tan α

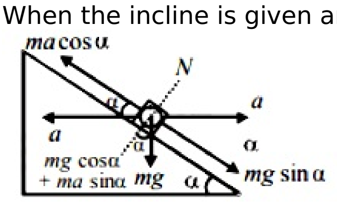
C. g tan α

D. g

Answer: C

Solution:

Solution:
When the incline is given an acceleration a towards the right, the block receives a reaction ma towards left.



For block to remain stationary, Net force along the incline should be zero.
$mg \sin \alpha = ma \cos \alpha \Rightarrow a = g \tan \alpha$

Question159

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 [2005]

Options:

A. $\mu_k = \sqrt{1 - \frac{1}{n^2}}$

B. $\mu_k = 1 - \frac{1}{n^2}$

C. $\mu_s = \sqrt{1 - \frac{1}{n^2}}$

D. $\mu_s = 1 - \frac{1}{n^2}$

Answer: B

Solution:

On smooth inclined plane, acceleration of the body $= g\sin\theta$. Let d be the distance travelled

$\therefore d = \frac{1}{2}(g\sin\theta)t_1^{\ 2}$,

$t_1 = \sqrt{\frac{2d}{g\sin\theta}}$,

On rough inclined plane,

$a = \frac{mg\sin\theta - \mu R}{m}$

$\Rightarrow a = \frac{mg\sin\theta - \mu mg\cos\theta}{m}$

$\Rightarrow a = g\sin\theta - \mu_k g\cos\theta$

$\therefore d = \frac{1}{2}\left(g\sin\theta - \mu\hat{k} g\cos\theta\right)t_2^{\ 2}$

$t_2 = \sqrt{\frac{2d}{g\sin\theta - \mu\hat{k} g\cos\theta}}$

According to question, $t_2 = nt_1$

$n\sqrt{\frac{2d}{g\sin\theta}} = \sqrt{\frac{2d}{g\sin\theta - \mu\hat{k} g\cos\theta}}$

Here, μ is coefficient of kinetic friction as the block moves over the inclined plane.

$\therefore \sin\theta = \left(\sin\theta - \mu\hat{k}\cos\theta\right)n^2$

$\Rightarrow n = \frac{1}{\sqrt{1-\mu_k}} \Rightarrow n^2 = \frac{1}{1-\mu_k}$

$\Rightarrow \mu_k = 1 - \frac{1}{n^2}$

Question160

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
[2005]

Options:

A. 2 cos ϕ

B. 2 sin ϕ

C. tan ϕ

D. 2 tan ϕ

Answer: D

Solution:

Solution:

For first half acceleration $= g\sin\phi$

For second half acceleration $= -(g\sin\phi - \mu g\cos\phi)$

For the block to come to rest at the bottom, acceleration in I half = retardation in II half.

$g\sin\phi = -(g\sin\phi - \mu g\cos\phi)$

$\Rightarrow \mu = 2 \tan \phi$

Question161

Consider a car moving on a straight road with a speed of 100 m/s . The distance at which car can be stopped is [μ_k = 5.0]
[2005]

Options:

A. 1000 m

B. 800 m

C. 400 m

D. 100 m

Answer: A

Solution:

Given, initial velocity, $u = 100 m / s$.
city, $v = 0$.
Acceleration, $a = \mu_k g = 0.5 \times 10$
$v^2 - u^2 = 2as$ or
$\Rightarrow 0^2 - u^2 = 2(-\mu_k g)s$
$\Rightarrow -100^2 = 2 \times -\frac{1}{2} \times 10 \times s$
$\Rightarrow s = 1000m$

Question162

An annular ring with inner and outer radii R_1 and R_2 is rolling without slipping with a uniform angular speed. The ratio of the forces experienced by the two particles situated on the inner and outer parts of the ring , $\frac{F_1}{F_2}$ is
[2005]

Options:

A. $\left(\frac{R_1}{R_2}\right)^2$

B. $\frac{R_2}{R_1}$

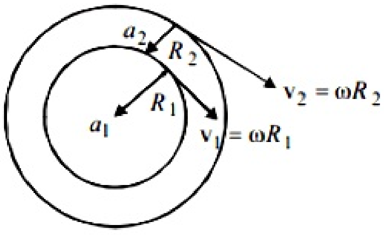
C. $\frac{R_1}{R_2}$

D. 1

Answer: C

Solution:

Solution:



Let m is the mass of each particle and ω is the angular speed of the annular ring.

$$a_1 = \frac{v_1^{\ 2}}{R_1} = \frac{\omega^2 R_1^{\ 2}}{R_1} = \omega^2 R_1$$

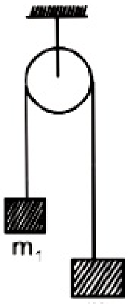
$$a_2 = \frac{v_2^{\ 2}}{R_2} = \omega^2 R_2$$

Taking particle masses equal

$$\frac{F_1}{F_2} = \frac{ma_1}{ma_2} = \frac{mR_1\omega^2}{mR_2\omega^2} = \frac{R_1}{R_2}$$

Question163

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



[2004]

Options:

A. 5 m/s^2

B. 9.8 m/s^2

C. 0.2 m/s^2

D. 4.8 m/s^2

Answer: C

Solution:

Solution:
Here, $m_1 = 5kg$ and $m_2 = 4.8kg$.
If a is the acceleration of the masses,

$m_1a = m_1g - T$ ......(i)
$m_2a = T - m_2g$ ......(ii)
Solving (i) and (ii) we get

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

$$\Rightarrow a = \frac{(5 - 4.8) \times 9.8}{(5 + 4.8)} m / s^2 = 0.2 m / s^2$$

Question164

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 $g = 10\ m / s^2$)
[2004]

Options:

A. 1.6

B. 4.0

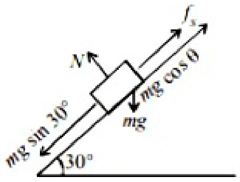
C. 2.0

D. 2.5

Answer: C

Solution:

Solution:



Since the body is at rest on the inclined plane,
$mg \sin 30° =$ Force of friction
$\Rightarrow m \times 10 \times \sin 30° = 10$
$\Rightarrow m \times 5 = 10 \Rightarrow m = 2.0 kg$

Question165

Which of the following statements is FALSE for a particle moving in a circle with a constant angular speed ?
[2004]

Options:

A. The acceleration vector points to the centre of the circle

B. The acceleration vector is tangent to the circle

C. The velocity vector is tangent to the circle

D. The velocity and acceleration vectors are perpendicular to each other.

Answer: B

Solution:

Solution:
Only option (b) is false since acceleration vector is always radial (i.e. towards the center) for uniform circular motion.

Question166

A rocket with a lift-off mass 3.5×10^4kg is blasted upwards with an initial acceleration of $10m / s^2$. Then the initial thrust of the blast is [2003]

Options:

A. 3.5×10^5N

B. 7.0×10^5N

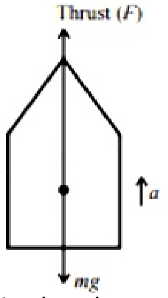
C. 14.0×10^5N

D. 1.75×10^5N

Answer: B

Solution:

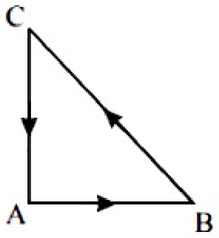
Solution:



In the absence of air resistance, if the rocket moves up with an acceleration a, then thrust
$F = mg + ma$
$\therefore F = m(g + a) = 3.5 \times 10^4(10 + 10)$
$= 7 \times 10^5$N

Question167

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. The particle will now move with velocity



[2003]

Options:

A. less than $\vec{v}$

B. greater than $\vec{v}$

C. $|\vec{v}|$ in the direction of the largest force BC

D. $\vec{v}$, remaining unchanged

Answer: D

Solution:

Solution:
Resultant force is zero, as three forces are represented by the sides of a triangle taken in the same order. From Newton's second law, $\vec{F}_{net} = m\vec{a}$.
Therefore, acceleration is also zero i.e., velocity remains unchanged.

Question168

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 [2003]

Options:

A. 24 N

B. 74 N

C. 15 N

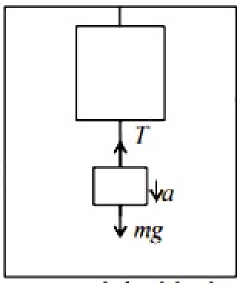
D. 49 N

Answer: A

Solution:

Solution:
When lift is stationary, $W_1 = mg$ ......(i)
When the lift descends with acceleration, a
$W_2 = m(g - a)$

$W_2 = \frac{49}{10}(10 - 5) = 24.5N$



Question169

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
[2003]

Options:

A. $\frac{Pm}{M + m}$

B. $\frac{Pm}{M - m}$

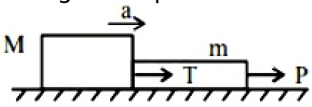
C. P

D. $\frac{PM}{M + m}$

Answer: D

Solution:

Solution:
Taking the rope and the block as a system



we get $P = (m + M)a$
$\therefore$ Acceleration produced, $a = \frac{P}{m + M}$
Taking the block as a system,
Force on the block, $F = Ma$
$\therefore F = \frac{MP}{m + M}$

Question170

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
[2003]

Options:

A. both the scales read M kg each

B. the scale of the lower one reads M kg and of the upper one zero

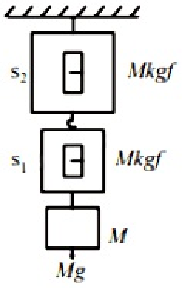
C. the reading of the two scales can be anything but the sum of the reading will be M kg

D. both the scales read M/2 kg each

Answer: A

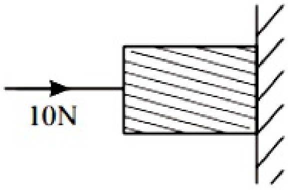
Solution:

Solution:
The Earth exerts a pulling force $M g$. The block in turn exerts a reaction force $M g$ on the spring of spring balance S_1 which therefore shows a reading of M kgf .
As both the springs are massless. Therefore, it exerts a force of $M g$ on the spring of spring balance S_2 which shows the reading of M kgf .



Question171

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



[2003]

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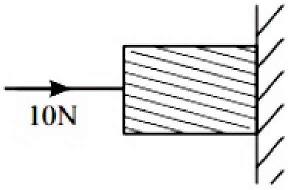


[2003]

Options:

A. 20 N

B. 50 N

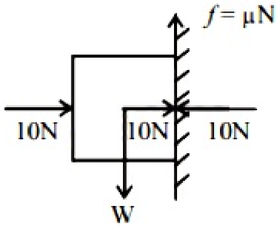
C. 100 N

D. 2 N

Answer: D

Solution:

Solution:
Horizontal force, $N = 10N$.
Coefficient of friction $\mu = 0.2$



The block will be stationary so long as
Force of friction = weight of block
$\therefore \mu N = W$
$\Rightarrow 0.2 \times 10 = W$
$\Rightarrow W = 2N$

Question172

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 [2003]

Options:

A. 0.02

B. 0.03

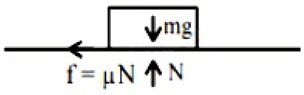
C. 0.04

D. 0.06

Answer: D

Solution:

Solution:
$u = 6m/s, v = 0, t = 10s, a = ?$
Acceleration $a = \frac{v-u}{t}$
$\Rightarrow a = \frac{0-6}{10}$
$\Rightarrow a = \frac{-6}{10} = -0.6m/s^2$



The retardation is due to the frictional force
$\therefore f = ma \Rightarrow \mu N = ma$
$\Rightarrow \mu mg = ma \Rightarrow \mu = \frac{ma}{mg}$
$\Rightarrow \mu = \frac{a}{g} = \frac{0.6}{10} = 0.06$

Question173

A solid sphere, a hollow sphere and a ring are released from top of an inclined plane (frictionless) so that they slide down the plane. Then maximum acceleration down the plane is for (no rolling)
[2002]

Options:

A. solid sphere

B. hollow sphere

C. ring

D. all same

Answer: D

Solution:

Solution:
This is a case of sliding (if plane is friction less) and therefore the acceleration of all the bodies is same.

Question174

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
[2002]

Options:

A. g, g

B. g – a, g – a

C. g – a, g

D. a, g

Answer: C

Solution:

Solution:
Case - I: For the man standing in the lift, the acceleration of the ball
$\vec{a}_{bm} = \vec{a}_b - \vec{a}_m \Rightarrow a_{bm} = g - a$
Case - II: The man standing on the ground, the acceleration of the ball
$\vec{a}_{bm} = \vec{a}_b - \vec{a}_m \Rightarrow a_{bm} = g - 0 = g$

Question175

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
[2002]

Options:

A. F_1 / m

B. $F_2 F_3 / mF_1$

C. $(F_2 - F_3) / m$

D. $\frac{F_2}{m}$.

Answer: A

Solution:

Solution:
When forces F_1, F_2 and F_3 are acting on the particle, it remains in equilibrium. Force F_2 and F_3 are perpendicular to each other,
$F_1 = F_2 + F_3$
$\therefore F_1 = \sqrt{F_2^2 + F_3^2}$
The force F_1 is now removed, so, resultant of F_2 and F_3 will now make the particle move with force equal to F_1.
Then, acceleration, $a = \frac{F_1}{m}$

Question176

Two forces are such that the sum of their magnitudes is 18 N and their resultant is 12 N which is perpendicular to the smaller force. Then the magnitudes of the forces are
[2002]

Options:

A. 12 N, 6 N

B. 13 N, 5 N

C. 10 N, 8 N

D. 16N, 2N

Answer: B

Solution:

Solution:
Let the two forces be F_1 and F_2 and let $F_2 < F_1$. R is the resultant force.
Given $F_1 + F_2 = 18$ ......(i)
From the figure $F_2^2 + R^2 = F_1^2$
$F_1^2 - F_2^2 = R^2$
$\therefore F_1^2 - F_2^2 = 144$ ....(ii)
Only option (b) follows equation (i) and (ii).

Question177

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
[2002]

Options:

A. 8 : 1

B. 9 : 7

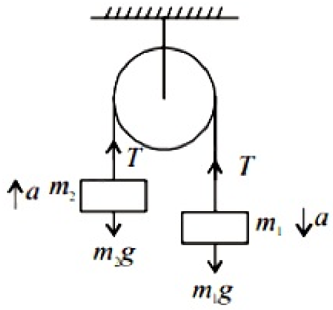
C. 4 : 3

D. 5 : 3

Answer: B

Solution:

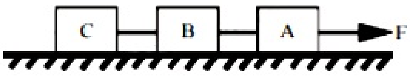
Solution:
For mass m_1
$m_1 g - T = m_1 a$ ....(i)
For mass m_2
$T - m_2 g = m_2 a$ ....(ii)



Adding the equations we get
$a = \frac{(m_1 - m_2)g}{m_1 + m_2}$
Here $a = \frac{g}{8}$
$\therefore \frac{1}{8} = \frac{\frac{m_1}{m_2} - 1}{\frac{m_1}{m_2} + 1} \Rightarrow \frac{m_1}{m_2} + 1 = 8\frac{m_1}{m_2} - 8 \Rightarrow \frac{m_1}{m_2} = \frac{9}{7}$

Question178

Three identical blocks of masses m = 2 kg are drawn by a force F = 10. 2 N 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?



[2002]

Options:

A. 9.2

B. 3.4

C. 4

D. 9.8

Answer: B

Solution:

Solution:

Force = mass × acceleration

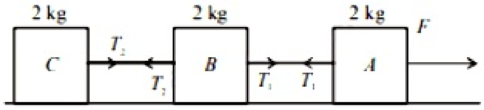
$\therefore F = (m + m + m) \times a$

$F = 3m \times a$

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

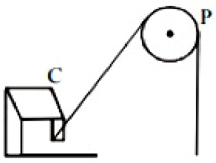
$\therefore a = \frac{10.2}{6} m/s^2$

$\therefore T_2 = ma = 2 \times \frac{10.2}{6} = 3.4N$



Question179

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 360 N. With what value of maximum safe acceleration (in ms^{-2}) can a man of 60 kg climb on the rope?



[2002]

Options:

A. 16

B. 6

C. 4

D. 8

Answer: C

Solution:

Tension, $T = 360N$
Mass of a man $m = 60kg$
$mg - T = ma$
$\therefore a = g - \frac{T}{m}$
$= 10 - \frac{360}{60} = 4m / s^2$

Question180

The minimum velocity (in ms^{-1}) with which a car driver must traverse a flat curve of radius 150 m and coefficient of friction0.6 to avoid skidding is [2002]

Options:

A. 60

B. 30

C. 15

D. 25

Answer: B

Solution:

The maximum velocity of the car is
$v_{max} = \sqrt{\mu rg}$
Here $\mu = 0.6, r = 150m, g = 9.8$
$v_{max} = \sqrt{0.6 \times 150 \times 9.8} \simeq 30m / s$
