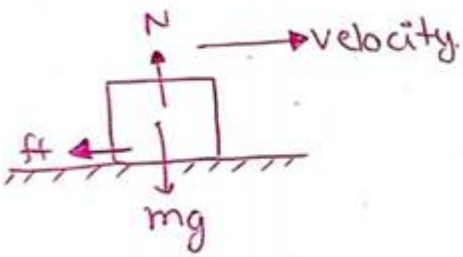
HC VERMA Solutions for Class 11 Physics Chapter 6 Friction

Question 1

A body slipping on a rough horizontal plane moves with a deceleration of 4.0 m/s^2. What is the coefficient of kinetic friction between the block and the plane?

Solution 1



Vertical equilibrium
N=mg

For horizontal; $F_{Net} =$ ma

$0 - ff = ma$

$-\mu N = ma$

$-\mu mg = ma$

$-\mu g = a$

$-\mu g = (-4)$

$\mu = 0.4\, m/s^2$

Question 2

A block is projected along a rough horizontal road with a speed of 10m/s. If the coefficient of kinetic friction is 0.10, how far it will travel before coming to rest?

Solution 2

Net force = max acceleration

$0 - ff = ma$

$-\mu mg = ma$

$-\mu g = a$

$-(0.1)(10) = a$

$a = -1\, m/s^2$

Now, $u = 10\,; a = -1\frac{m}{s^2}; v = 0$

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

$0 = (10)^2 + 2(-1)s$

s=50m

Question 3

A block of mass m is kept on a horizontal table. If the static friction coefficient is μ, find the frictional force acting on the block.

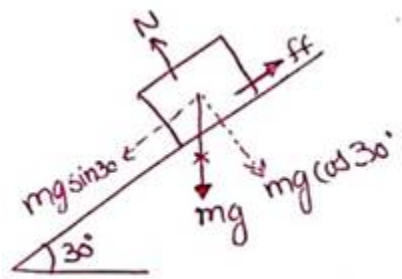
Solution 3

Since no driving force is present to move the block. So, frictional force will be zero.

Question 4

A block slides down an inclined surface of inclination 30° with the horizontal. Starting from rest it covers 8 m in the first two seconds. Fins the coefficient of kinetic friction between the two.

Solution 4



$N = mg\cos 30° \qquad -(i)$

$F_N = ma$

$mg\sin 30 - ff = ma$

$mg\sin 30 - \mu_k N = ma$

$mg\sin 30 - \mu_k mg\cos 30 = ma$

$g\sin 30 - \mu_k g\cos 30 = a \qquad -(ii)$

Now,

$u = 0\,; s = 8m; t = 2s$

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

$8 = 0 + \frac{1}{2}(a)(2)^2$

$a = 4\frac{m}{s^2} \qquad -(iii)$

From (ii) and (iii)

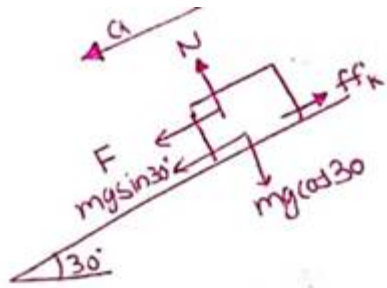
$4 = g\sin 30° - \mu_k g\cos 30°$

$\mu_k =$ 0.11

Question 5

Suppose the block of the previous problem is pushed down the incline with a fame of 4 N. How far will the block move in the first two seconds after starting from rest? The mass of the block is 4 kg.

Solution 5



Along inclined plane

$F_N = ma$

$F + mg\sin 30 - ff_k = ma$

$4 + 4(10)\left(\frac{1}{2}\right) - \mu_k mg\cos 30° = ma$

$24 - 0.11 \times 4 \times 10 \times \frac{\sqrt{3}}{2} = 4a$

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

Now,

$u = 0\frac{m}{s}; t = 2s; a = 5\,m/s^2$

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

$s = 0 + \frac{1}{2}(5)(2)^2$

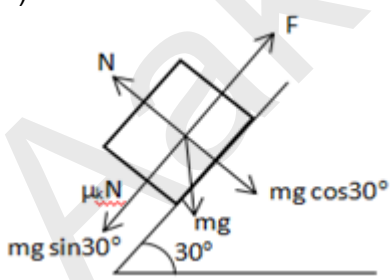
s=10 m

Question 6

A body of mass 2 kg is lying on a rough inclined plane of inclination 30°. Find the magnitude of the force parallel to the incline needed to make the block move (a) up the incline (b) down the incline. Coefficient of static friction = 0.2.

Solution 6

a)



Applied force must be greater than net force which is acting downwards to make to move up.

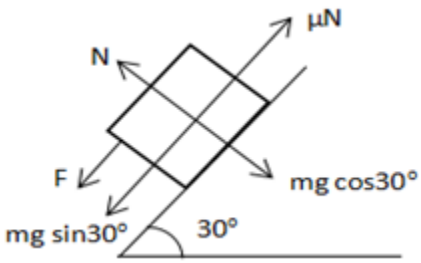
$F_{req} = \mu N + mg\sin 30°$

$N = mg\cos 30°$

$M = 2kg$, $g = 9.8 m/s^2$, $\mu = 0.2$

On substituting, $F_{req} = 13N$.

b)

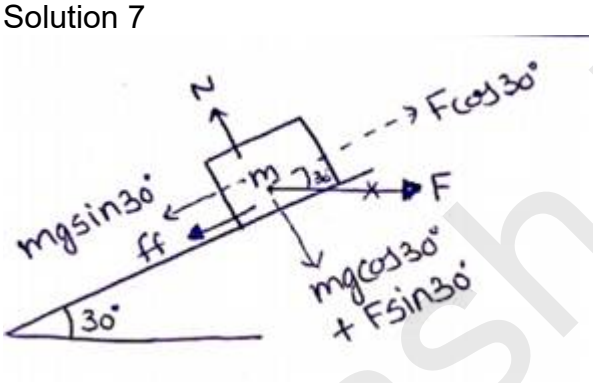


Net force acting down the incline is given by
F_{net} = 2gsin30° - μN
= 2×9.8×1/2 - (0.2)[mgcos30°]
= 9.8 - 0.2[2×9.8×√3/2]
= 6.41N
6.41 is the force acting down the inclined plane.
This is enough for the body to slide down. No need to exert extra force. So, force required is zero.

Question 7

Repeat part (a) of the problem 6 if the push is applied horizontally and not parallel to the incline.

Solution 7



Since the block is just to move up the incline so frictional force will act in downward direction.
Since, block is in equilibrium.

$N = mg\cos 30° + F\sin 30°$ ……(perpendicular to incline)

$F\cos 30° = mg\sin 30° + ff$ ……..(along the incline)

Now,

$F\cos 30° = mg\sin 30° + \mu N$

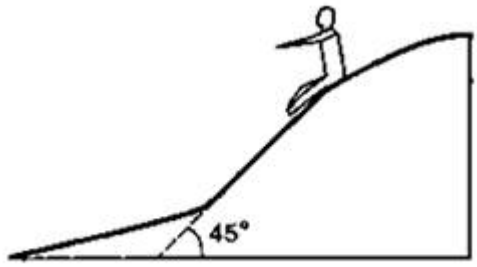
$F\cos 30° = mg\sin 30° + \mu(mg\cos 30° + F\sin 30)$

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

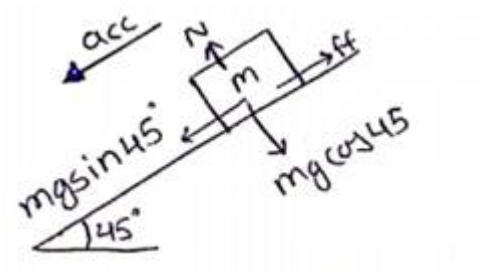
F=17.5 N

Question 8

In a children-park an inclined plane is constructed with an angle of incline 45° in the middle part. Find the acceleration of a boy sliding on it if the friction coefficient between the cloth of the boy and the incline is 0.6 and g = 10 m/s^2.



Solution 8



$N = mg\cos 45°$ ……(perpendicular to incline)

$mg\sin 45 - ff = ma$ ….(along the incline)

$mg\sin 45 - \mu N = ma$

$mg\sin 45 - \mu mg\cos 45 = ma$

$g\sin 45 - \mu g\cos 45 = a$

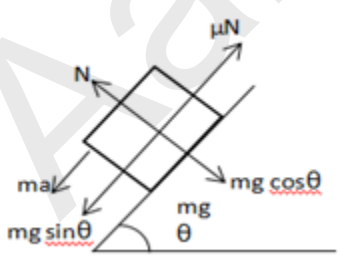
$10 \times \frac{1}{\sqrt{2}} - 0.6 \times 10 \times \frac{1}{\sqrt{2}} = a$

$a = 2\sqrt{2}\, m/s^2$

Question 9

A body starts slipping down an incline and moves half meter in half second. How long will it take to move the next half meter?

Solution 9



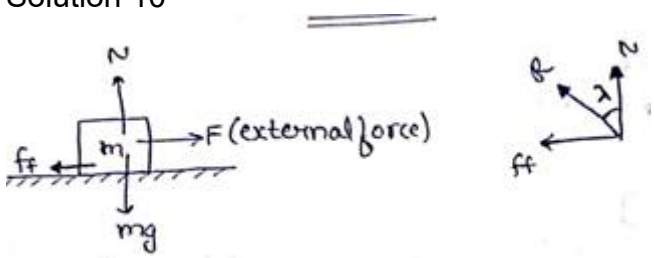
In the first half metre,
u=0m/s, s=0.5m, t=0.5s
v=u+at

v= 0+(0.5×4) = 2m/s
s=ut+1/2at^2
0.5=0+12(a)(0.5)^2
a=4m/s^2
For the next half metre, u=2m/s , a=4m/s^2, s=0.5m
0.5 = 2t+(1/2)(4)t^2
4t^2+4t-1=0
On solving, t=0.2027 sec
Time taken to cover the next half metre is 0.21s.

Question 10

The angle between the resultant contact force and the normal force exerted by a body on the other is called the angle of friction. Show that if λ be the angle of friction and μ the coefficient of static friction, λ ≤ tan-1 μ

Solution 10



Angle of friction, $\tan\lambda = \frac{ff}{N}$

The value of friction force depends upon external force applied. If the body does not move then $(ff = F) < (ff_{(lm)} = \mu N)$.

When body is about to move or moves then ff=$ff_{(lm)}$= μN
So,
ff<=μN

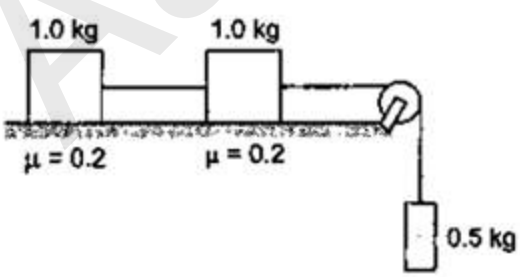
$\therefore \tan\lambda \leq \frac{\mu N}{N}$

$\tan\lambda \leq \mu$

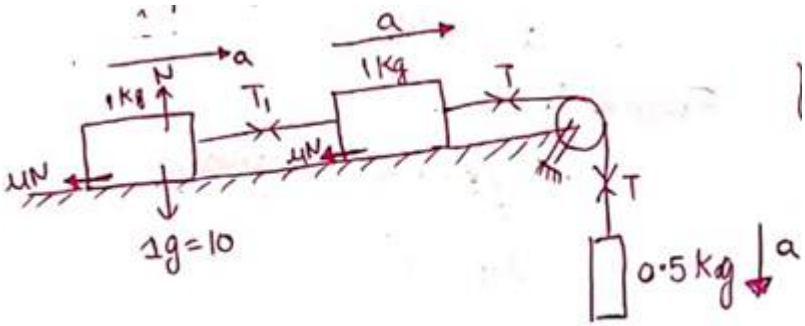
λ≤tan^{-1}(μ)

Question 11

Consider the situation shown in figure. Calculate (a) the acceleration of the 1.0 kg blocks, (b) the tension in the string connecting the 1.0 kg blocks and (c) the tension in the string attached to 0.50 kg.



Solution 11



For mass 0.5 Kg

$mg - T = ma$

$0.5g - T = 0.5a \quad -(i)$

for 1 Kg night mass

$T - T_1 - \mu N = ma$

$T - T_1 - 0.2 \times 10 = 1 \times a$

$T - T_1 = 2 + a \quad -(ii)$

For 1 Kg left mass

$T_1 - \mu N = ma$

$T_1 - 0.2 \times 10 = 1 \times a \quad -(iii)$

Solving (i), (ii) and (iii)

$a = 0.4\, m/s^2$

$T_1 = 2.4N$

$T_2 = 4.8N$

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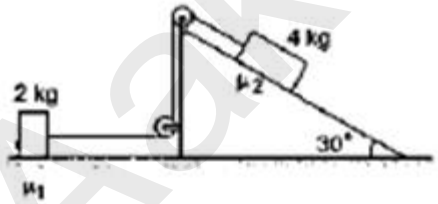
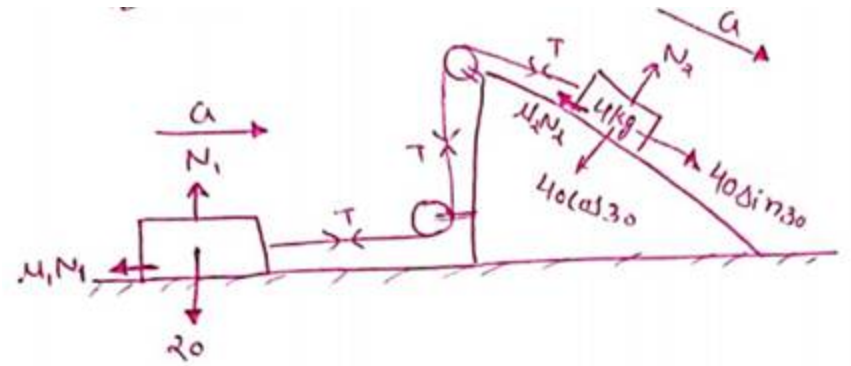
Question 12

If the tension in the string in figure is 16 N and the acceleration of each block is 0.5 m/s^2, find the friction coefficients at the two contacts with the blocks.



Solution 12



For 2Kg block

$T - \mu_1 N_1 = 2 \times a$

$16 - \mu_1(20) = 2 \times (0.5)$

$15 = 20\mu_1$

$\mu_1 = 0.75$

For 4Kg block

$40 \sin 30 - T - \mu_2 N_2 = 4a$

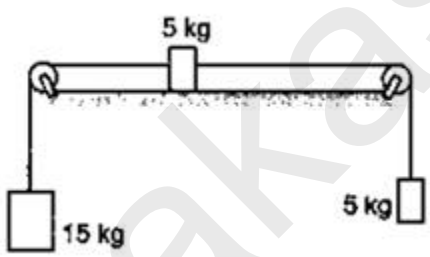
$40 \times \left(\frac{1}{2}\right) - T - \mu_2(40\cos 30) = 4a$

$20 - 16 - \mu_2 \times 40 \times \frac{\sqrt{3}}{2} = 4 \times 0.5$

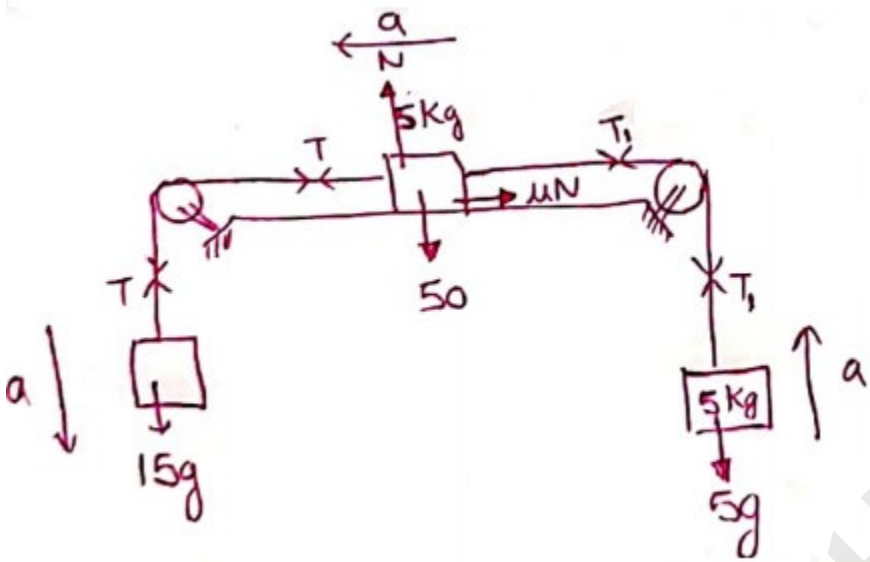
$\mu_2 = 0.06$

Question 13

The friction coefficient between the table and the blockshown in figure is 0.2. Find the tensions in the two strings.



Solution 13



$15g - T = 15a \quad -(i)$

$T - T_1 - \mu N = 5a \ \& \ \mu N = 0.2 \times 5g = g$

$T - T_1 - g = 5a \quad -(ii)$

$T_1 - 5g = 5a \quad -(iii)$

Adding (i), (ii) and (iii)
15g-g-5g=15a+5a+50
9g=25a

$a = \frac{9g}{25}$

Now, put in eq.(i)

$T = 15g - 15(\frac{9g}{25})$

$T = \frac{75g - 27g}{5}$

T= 96 N
From eq.(3)

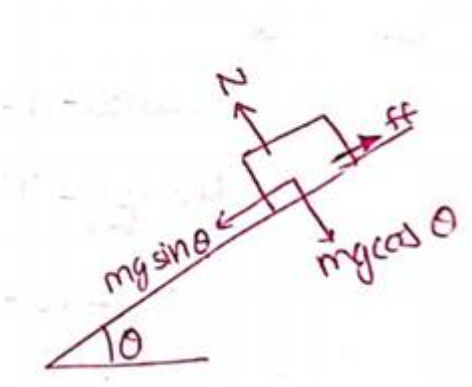
$T_1 = 5g + 5 \times \frac{9g}{25}$

T_1=68N

Question 14

The friction coefficient between a road and the type of a vehicle is 4/3. Find the maximum incline the road may have so that once hard brakes are applied and the wheel starts skidding, the vehicle going down at a speed of 36 km/hr is stopped within 5 m.

Solution 14



$u = 36 \times \frac{5}{18} = 10\ m/s$

$v = 0\,; s = 5m$

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

$0^2 = (10)^2 + 2(a)(5)$

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

Now, by translatory motion equation

$mg\sin\theta - ff = ma$

$mg\sin\theta - \mu N = ma$

$mg\sin\theta - \mu mg\cos\theta = ma$

$10\sin\theta - \frac{4}{3} \times 10 \times \cos\theta = (-10)$

$\sin\theta + 1 = \frac{4}{3}\sqrt{1 - \sin^2\theta}$

Squaring

$9(1 + \sin\theta)^2 = 16(1 - \sin^2\theta)$

$9(1 + \sin^2\theta + 2\sin\theta) = 16 - 16\sin^2\theta$

$25\sin^2\theta + 18\sin\theta - 7 = 0$

On solving,

$\theta = 16°$

Question 15

The friction coefficient between an athelete's shoes and the ground is 0.90. Suppose a superman wears these shoes and races for 50 m. There is no upper limit on his capacity of running at high speeds. (a) Find the minimum time that he will have to take in completingthe 50 m starting from rest. (b) Suppose he takes exactly this minimum time to complete the 50 m, what minimum time will he take to stop?

Solution 15

(a) frictional force exerted by ground will be in forward direction.

$ff = ma$

$\mu N = ma$

$\mu mg = ma$

$a = \mu g = 0.9 \times 10 = 9\, m/s^2$

$u = 0\,;\, a = 9\,\frac{m}{s^2};\; s = 50\, m$

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

$50 = 0 + \frac{1}{2}(9)(t)^2$

$t = \frac{10}{3}$ sec

(b) While stopping, frictional force will act in opposite direction of motion.

$0 - ff = ma$

$-\mu N = ma$

$-\mu mg = ma$

$a = -\mu g = -0.9 \times 10 = -9\, m/s^2$

After covering 50m, the velocity of athelete is

$v = u + at$

$= 0 + 9 \times \frac{10}{3}$

$v = 30\, m/s$

Now,

$u = 30\frac{m}{s}; v = 0\,; a = -9\, m/s^2$

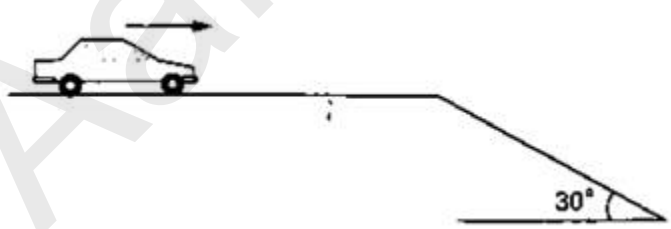
$v = u + at$

$0 = 30 - 9 \times t$

t=3.33 sec

Question 16

A car is going at a speed of 21.6 km/hr when it encounters a 12.8 m long slope of angle 30°. The friction co-efficient between the road and the tyre is $\frac{\sqrt{3}}{2}$. Show that no matter how hard the driver applies the brakes, the car will reach the bottom with a speed greater than 36 km/hr. Take g=10 m/s^2.



Solution 16

When driver applies brakes frictional force will be opposite to motion of car.

$a = g\sin 30° - \mu g \cos 30°$

$$= \frac{g}{2} - \frac{1}{2\sqrt{3}} . g(\frac{\sqrt{3}}{2})$$

$$a = \frac{g}{4} = \frac{10}{4} = 2.5\, m/s^2$$

$$u = 21.6 \frac{km}{hr} = 21.6 \times \frac{1000}{60 \times 60} = 6\, m/s$$

s=12.8

We know that,

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

$$v^2 = (6)^2 + 2(2.5)(12.8)$$

$$v^2 = 100$$

$$v = 10\, m/s$$

$$v = 10 \times \frac{18}{5}$$ Kmph

v=36 Kmph

Question 17

A car starts from rest on a half kilometre long bridge. The co-efficient of friction between the tyre and the road is 1.0. Show that one cannot drive through the bridge is less than 10s.

Solution 17

The maximum acceleration for car is given by,

$$a = \mu g = 1 \times 10 = 10\, m/s^2$$

$$u = 0$$

$$s = 500\, m$$

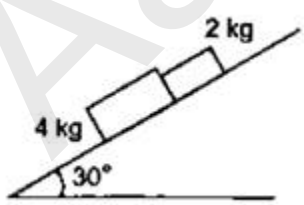
$$s = ut + \frac{1}{2} at^2$$

$$500 = 0 + \frac{1}{2} \times 10 \times t^2$$

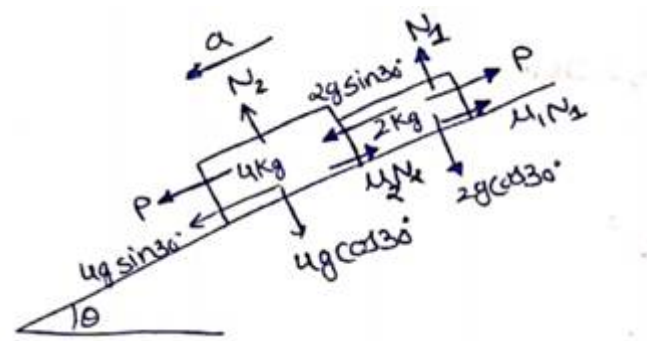
t=10 sec

Question 18

Figure shows two blocks in contact sliding down an inclined surface of inclination 30°. The friction coefficient between the block of mass 2.0 kg and theincline is p and that between the block of mass 4.0 kg and the incline is μ. Calculate the acceleration of the 2.0 kg block if (a)μ1 = 0.20 and μ2 = 0.30, (b) μ1 = 0.30 and μ2 = 0.20. Take g =10m/s^2.



Solution 18



P is the contact force.
$N_1 = 4g\cos 30$

$N_1 = 4 \times 10 \times \frac{\sqrt{3}}{2} = 20\sqrt{3}$ N

for 4Kg block
$P + 4g\sin 30 - \mu_2 N_2 = ma$

$P + 4 \times 10 \times \frac{1}{2} - (0.3)(20\sqrt{3}) = 4a$

$P = 4a + 6\sqrt{3} - 20 \qquad -(i)$

For 2Kg block
$N_1 = 2g\cos 30 = 10\sqrt{3}$

$2g\sin 30 - P - \mu_1 N_1 = 2a$

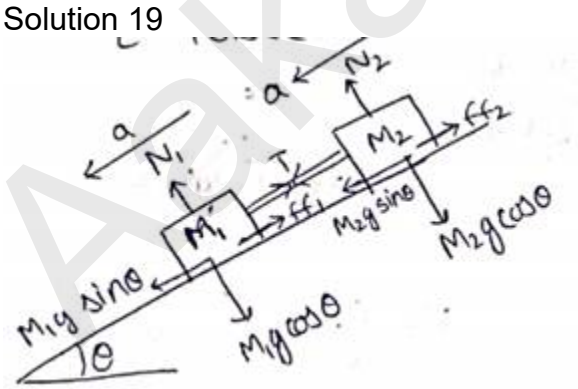
$P = 2a + 10 + 2\sqrt{3} \qquad -(ii)$

On solving (i) and (ii)
$a = 2.7\, m/s^2$

Question 19

Two masses M_1 and M_2 are connected by a light rod and the system is slipping down a rough incline of angle θ with the horizontal. The friction coefficient at both the contacts is μ. Find the acceleration of the system and the force by the rod on one of the blocks.

Solution 19



Both blocks are connected by rod.
So, there acceleration must be same.
$M_1 g\sin\theta - T - ff_1 = M_1 a$ -----(1)

$ff_1 = \mu N_1 = \mu M_1 g \cos\theta$ ------(2)

$M_2 g \sin\theta - T - ff_2 = M_2 a$ ------(3)

$ff_2 = \mu N_2 = \mu M_2 g \cos\theta$ -------(4)

Add (1) and (3)

$M_1 g \sin\theta + M_2 g \sin\theta - ff_1 - ff_2 = (M_1 + M_2)a$

$(M_1 + M_2) g \sin\theta - \mu g \cos\theta\,(M_1 + M_2) = (M_1 + M_2)a$

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

Put in equation (1)

$M_1 g \sin\theta - T - \mu M_1 g \cos\theta = M_1(g \sin\theta - \mu g \cos\theta)$

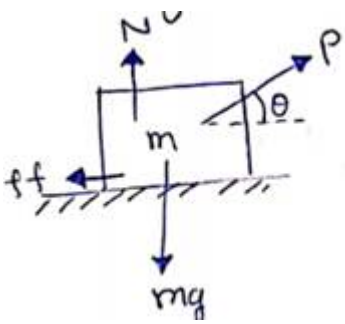
T=0

Question 20

A block of mass Mis kept on a rough horizontal surface. The coefficient of static friction between the block and the surface is p. The block is to be pulled by applying a force to it. What minimum force is needed to slide the block? In which direction should this force act?

Solution 20

Let minimum force required be P at an angle θ.



$N + P\sin\theta = mg$ (vertical equilibrium) -(i)

$P\cos\theta = \mu N$ (Body is about to move) -(ii)

From (i)

$P\cos\theta = \mu(mg - P\sin\theta)$

$P = \frac{\mu mg}{\cos\theta + \mu\sin\theta}$ -(iii)

To minimize P, we have to maximize $y = \cos\theta + \mu\sin\theta$

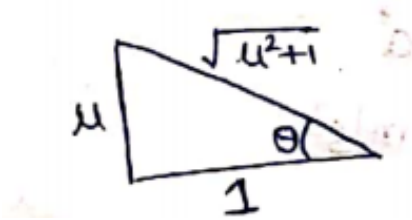
$\frac{dy}{d\theta} = \frac{d}{d\theta}(\cos\theta + \mu\sin\theta)$

$\frac{dy}{d\theta} = -\sin\theta + \mu\cos\theta = 0$

$\tan\theta = \mu$

$\theta = \tan^{-1}\mu$

Maximum value of $y = \frac{1}{\sqrt{\mu^2+1}} + \mu.\frac{\mu}{\sqrt{\mu^2+1}}$



$y_{max} = \sqrt{1+\mu^2}$

Put in (3)

So, $P_{min} = \frac{\mu mg}{\sqrt{1+\mu^2}}$ at $\theta = \tan^{-1}\mu$

Question 21

The friction coefficient between the board and the floor shown in figure is IA. Find the maximum force that the man can exert on the rope so that the board does not slip on the floor.

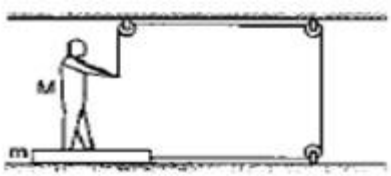
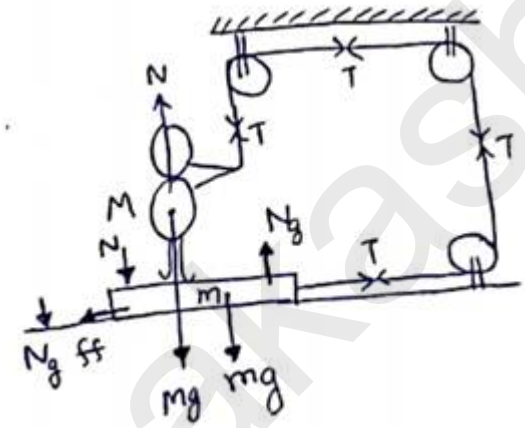


Figure 6-E7

Solution 21



For man

N+T=Mg

For board

$N_g = N + mg$ (vertical equilibrium)

$T = ff = \mu N_g$ (Horizontal equilibrium)

$T = \mu(N + mg)$

$T = \mu(Mg - T + mg)$

$$T = \frac{\mu(M+m)g}{1+\mu}$$

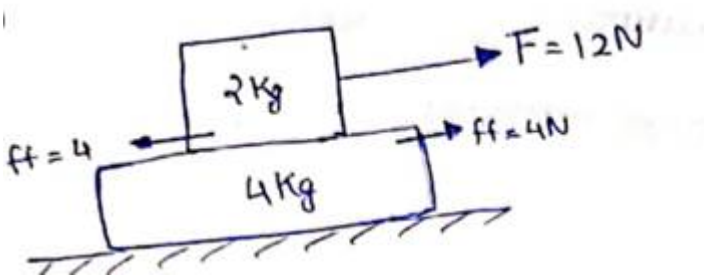
It is maximum force exerted by man.

Question 22

A 2 kg block is placed over a 4 kg block and both are placed on a smooth horizontal surface. The coefficient of friction between the blocks is 0.20. Find the acceleration of the two blocks if a horizontal force of 12 N is applied to (a) the upper block, (b) the lower block. Take g= 10 m/s^2.

Solution 22

(a)



Normal contact for 2Kg = 2g =20 N.

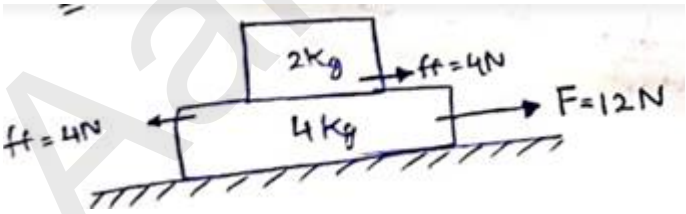
Maximum friction force between 2Kg and 4Kg= μN
$= 0.2(20)$

= 4 N
Since F=12 N >ff bond will break
for 2Kg block,
12-4=2a
8=2a
$a = 4\,m/s^2$

for 4Kg block,

4-0=4a'
$a' = 1\,m/s^2$

(b)



Individual acc.
for 4Kg block,
12-4=4a
$a = 2\,m/s^2$

for 2Kg block,

4-0=2a'

$a' = 2 m/s^2$

So, acceleration of both blocks are $2\ m/s^2$.

Question 23

Find the accelerations a_1, a_2, a_3 of the three blocks shown in figure (6-E8) if a horizontal force of 10 N is applied on (a) 2 kg block, (b) 3 kg block, (c) 7 kg block. Take g= 10m/s^2.

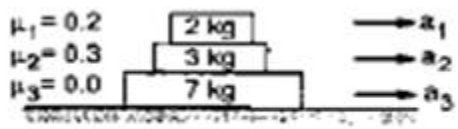
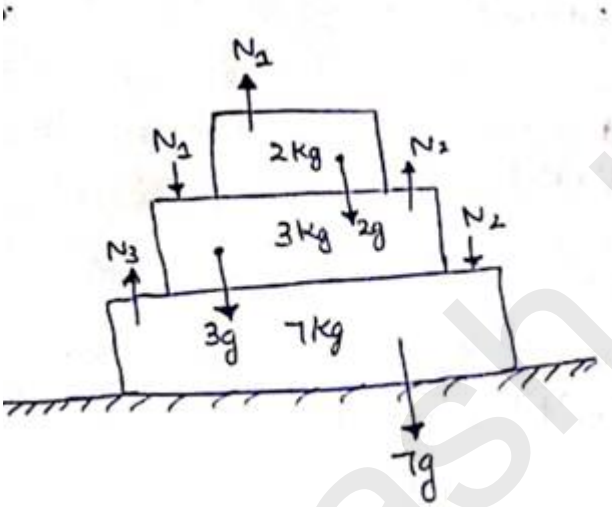


Figure 6-E8

Solution 23



For 2Kg;

$N_1 = 2g = 20N$;

$ff_1 = \mu_1 N_1 = 0.2 \times 20 = 4N$

For 3Kg;

$N_2 = N_1 + 3g = 20 + 30 = 50N$

$ff_2 = \mu_2 N_2 = 0.3 \times 50 = 15N$

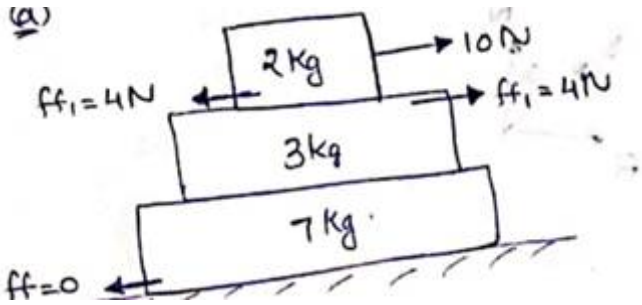
For 7Kg;

$N_3 = N_2 + 7g = 50 + 70 = 120N$

$ff_3 = \mu_3 N_3 = 0$

(a)

(a)



The bond between 2Kg and 3Kg breaks as applied force is more than limiting friction.

Acceleration of 2Kg block $\Rightarrow F_N = 10 - ff_1$

$m \times a_1 = 10 - 4$

$2 \times a_1 = 6$

$a_1 = 3\, m/s^2$

Bond between 3Kg and 7Kg will not be broken by 4N force so both will move together.

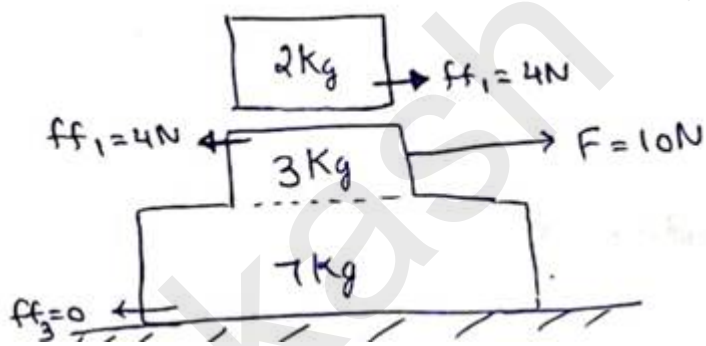
Acceleration of 3Kg and 7Kg block $\Rightarrow F_N = 4 - 0$

$ma_2 = 4$

$(3+7)a_2 = 4$

$a_3 = a_2 = 0.4\, m/s^2$

(b) The bond between 3Kg and 7Kg will not be broken so they will definitely move together.
Now individual acceleration



For 2Kg;

$ff_1 - 0 = 2 \times a_1$

$4 = 2 \times a_1$

$a_1 = 2\, m/s^2$

For 3Kg and 7Kg;

$F - ff_1 - ff_3 = (3+7)a_2$

$10 - 4 - 0 = 10a_2$

$a_2 = 0.6\, m/s^2$

Acceleration of 2Kg block cannot be greater than 3Kg block.
So, all will move together.

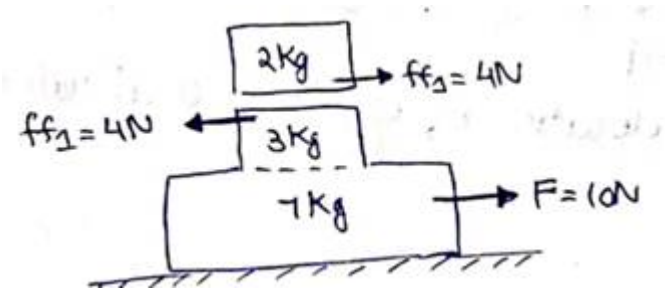
$F_N = m \times acceleration$

$10 - 0 = (2 + 3 + 7)a$

$a = \frac{5}{6}\, m/s^2$

So, $a_1 = a_2 = a_3 = \frac{5}{6}\, m/s^2$

(c) The bond between 3Kg and 7Kg will not be broken as applied force (10N) is less than $ff_2 = 15N$. So, both of them moves together.
Now, individual acceleration



For 2Kg;
$ff_1 - 0 = 2 \times a_1$

$4 = 2 \times a_1$

$a_1 = 2\, m/s^2$

For 3Kg and 7Kg;
$F - ff_1 - ff_3 = (3 + 7)a_2$

$10 - 4 - 0 = 10a_2$

$a_2 = 0.6\, m/s^2$

Acceleration of 2Kg block cannot be greater than 3Kg block.
So, all will move together.
$F_N = m \times acceleration$

$10 - 0 = (2 + 3 + 7)a$

$a = \frac{5}{6}\, m/s^2$

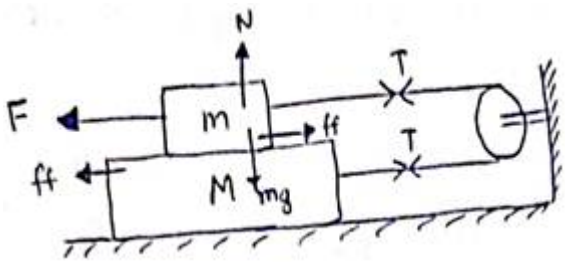
So, $a_1 = a_2 = a_3 = \frac{5}{6}\, m/s^2$.

Question 24

The friction coefficient between the two blocks shown in figure is μ but the floor is smooth.
(a) What maximum horizontal force F can be applied without disturbing the equilibrium of the system?
(b) Suppose the horizontal force applied is double of that found in part (a) Find the accelerations of the two masses.

Figure 6-E9

Solution 24



(a)For block m;
N=mg
ff=μN=μmg
F=T + ff (∴ acceleration = μ) -(i)
For block M;
T=ff (∴ acceleration = 0) -(ii)
Solving (i)and(ii),
F=ff + ft
F=2μmg

(b) Now applied force is F=2(2μmg)=4μmg
For block m;
F-T-ff=ma -(i)
For block M;
T-ff=Ma -(ii)
Adding (i)and(ii),
F-2ff =(m + M)a
4μmg-2μmg = (m + M)a
$a = \frac{2\mu mg}{(m+M)}$ in opposite directions.

Question 25

Suppose the entire system of the previous question is kept inside an elevator which is coming down with an acceleration a < g.Repeat parts (a) and (b).

Solution 25

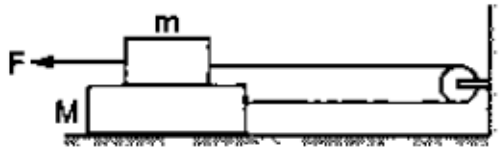
In elevator, moving down with acceleration a, effective acceleration will be
$g_{eff} = g - a$

So, replace g by g_{eff} in above answers.

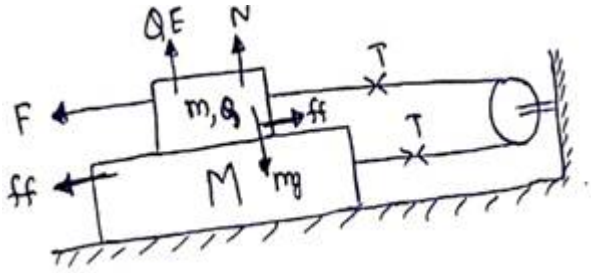
Question 26

Consider the situation shown in figure. Suppose a small electric field Eexists in the space in the vertically upward direction and the upper block carries a positive charge Q on its top surface. The

friction coefficient between the two blocks is g but the floor is smooth. What maximum horizontal force Fcan be applied without disturbing the equilibrium?
[Hint: The force on a charge Q by the electric field E is F = *QE*in the direction of *E*.]



Solution 26

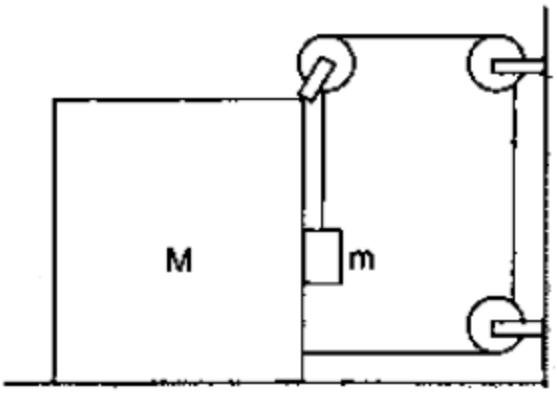


For block m,
QE+N=mg (vertical equilibrium)
N=mg-QE
$ff = \mu N = \mu(mg - QE)$
F=T + ff (Horizontal equilibrium) -(i)
For block M,
T=ff (Horizontal Equilibrium) -(ii)
Solving (i)and(ii),
F=ff + ft
F=2ff = 2μ(mg-QE)

Chapter 6 - Friction Exercise 99

Question 27

A block of mass m slips on a rough horizontal table under the action of a horizontal force applied to it. The coefficient of friction between the block and the table is g. The table does not move on the floor. Find the total frictional force applied by the floor on the legs of the table. Do you need the friction coefficient between the table and the floor or the mass of the table?

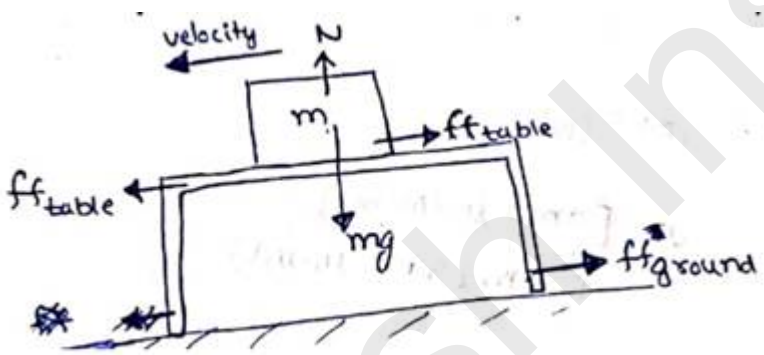


Solution 27

When block slips, the limiting friction force acts.

$ff_{table} = \mu N$

$ff_{table} = \mu mg$



Since the table remains at rest.

$ff_{table} = ff_{ground}$

$ff_{ground} = \mu mg$

Question 28

Find the acceleration of the block of mass *M* in the situation of figure. The coefficient of friction between the two blocks is μ1, and that between the bigger block and the ground is μ2.

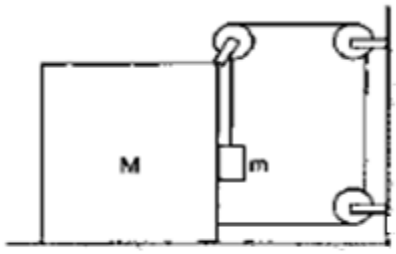
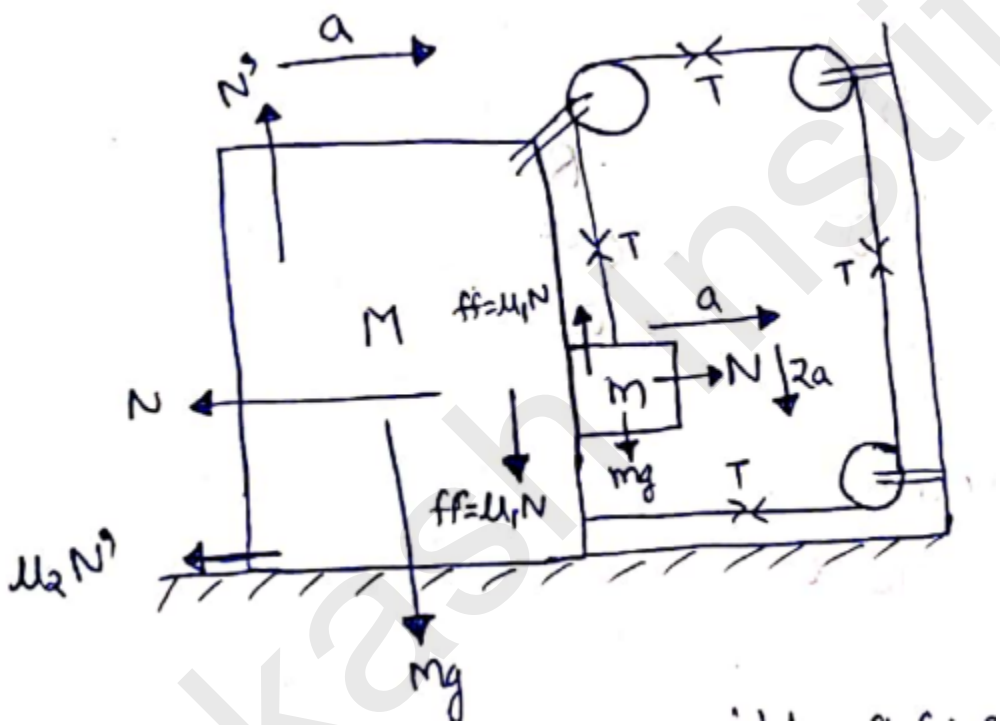


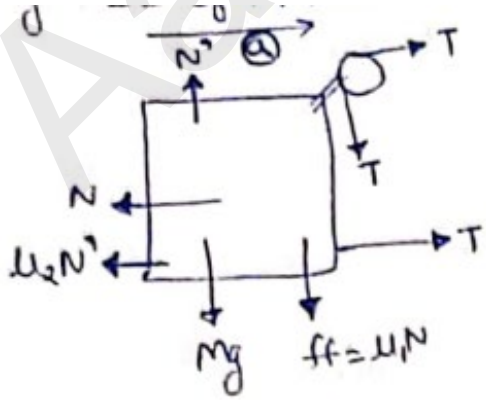
Figure 6-E10

Solution 28

When a block M, moves with acceleration a towards right block m moves downwards and rightwards with acceleration 2a and a respectively.



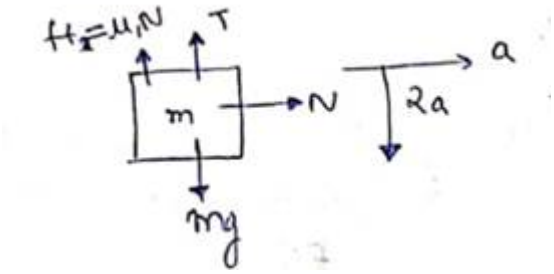
Drawing FBD of M mass



$N' = Mg + \mu_1 N + T$ (Vertical) -(i)

$(T + T) - N - \mu_2 N' = Ma$ (Horizontal) -(ii)

FBD of mass m



N=ma (Horizontal) -(iii)

$mg - T - \mu_1 N = m(2a)$ (vertical) -(iv)

From (iii) and (iv)

$T = mg - 2ma - \mu_1 ma$ -(v)

Solving equation (i), (ii), (iii) and (iv)

$$a = \frac{[2m - \mu_2(M+m)]g}{M + m[5 + 2(\mu_1 - \mu_2)]}$$

Question 29

A block of mass 2 kg is pushed against a rough vertical wall with a force of 40 N, coefficient of static friction being 0.5. Another horizontal force of 15 N, is applied on the block in a direction parallel to the wall. Will the block move? If yes, in which direction? If no, find the frictional force exerted by the wall on the block.

Solution 29

Net driving force on the block

$F_{driving} = \sqrt{(mg)^2 + (15)^2}$

$= \sqrt{(2 \times 10)^2 + (15)^2} = 25N$

Limiting friction force= $\mu R = 0.5 \times 40 = 20N$

$\because\ F_{driving} > ff_{(lm)}$ block will move.

For acceleration,

$F_{Net} = 25 - 20$

$m \times a = 5$

$2 \times a = 5$

$a = 2.5\, m/s^2$

Direction w.r.t 15N force

$\tan\phi = \frac{20}{15} = \frac{4}{3}$

$\phi = 53°$ with 15N force.

Question 30

A person (40 kg) is managing to be at rest between two vertical walls by pressing one wall A by his hands and feet and the other wall Bby his back. Assume that the friction coefficient between his body and the walls is 0.8 and that limiting friction acts at all the contacts.
(a) Show that the person pushes the two walls with equal force.
(b) Find the normal force exerted by either wall on the person. Take g = 10 m/s^2.

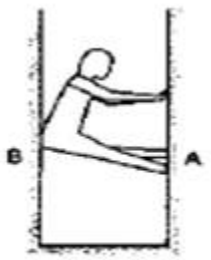
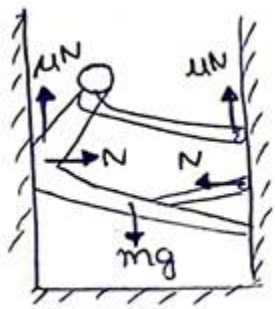


Figure 6-E11

Solution 30



(a) Since the man is at rest horizontally. So, both by both walls on man will be equal and opposite in direction.

(b) In vertical equilibrium condition

$2\mu N = mg$

$2 \times 0.8 \times N = 40 \times 10$

N=250 N

Question 31

Figure shows a small block of mass m kept at the left end of a larger block of mass Mand length l. The system can slide on a horizontal road. The system is started towards right with an initial velocity v. The friction coefficient between the road and the bigger block is μ and that between the block is μ/2. Find the time elapsed before the smaller blocks separates from the bigger block.

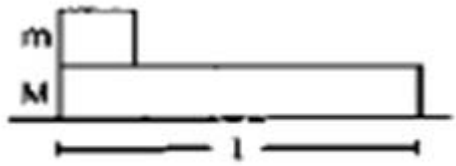


Figure 6-E12

Solution 31

Initial velocity of both blocks is same. So, $U_{rel} = 0$

When m separates from M. $S_{rel} = l$

Let a_m and a_M be the acceleration of the blocks m and M respectively with respect to ground.

Here, $a_m > a_M$ as both blocks separates from each other.

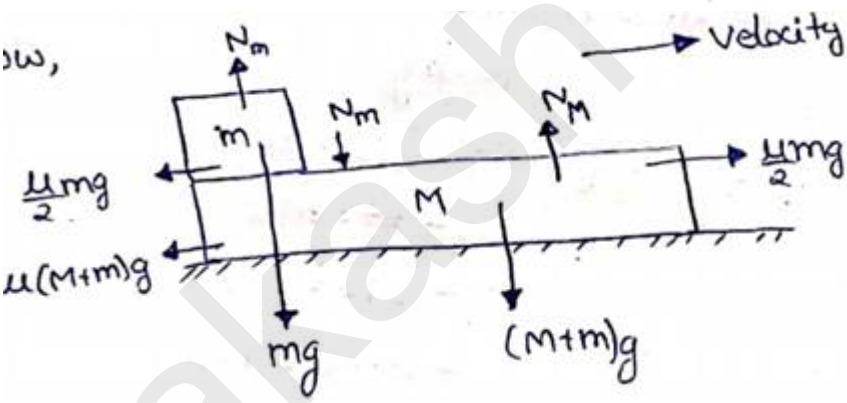
So, $a_{rel} = a_m - a_M$

$$S_{rel} = U_{rel}t + \frac{1}{2}a_{rel}t^2$$

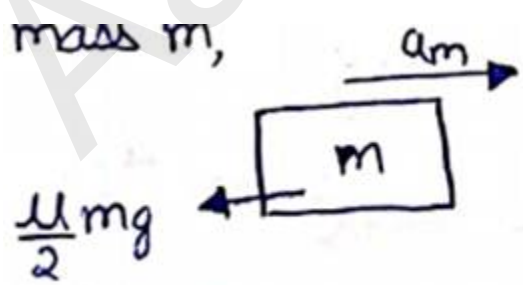
$$l = 0 + \frac{1}{2}(a_m - a_M)t^2$$

$$t = \sqrt{\frac{2l}{(a_m - a_M)}}$$ -(i)

Now,



FBD of mass m,

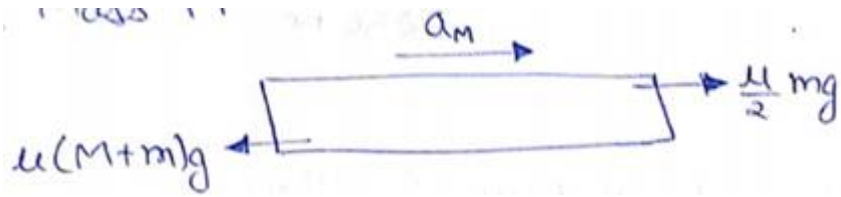


$F_N = mass \times acceleration$

$ma_m = 0 - \frac{\mu}{2}mg$

$a_m = \frac{-\mu g}{2}$ -(ii)

FBD of mass M



$Ma_M = \frac{\mu}{2}mg - \mu(M+m)g$

$a_M = -\mu g - \frac{\mu mg}{2M}$ -(iii)

Subtract (ii) and (iii)

$a_m - a_M = \frac{\mu g}{2} + \frac{\mu mg}{2M}$

Put in e.q. (i)

$t = \sqrt{\frac{4Ml}{(M+m)\mu g}}$