Friction

Exercise Solutions

Solution 1:
Given:
The deceleration of body due to friction (a) = 4.0 m/s^2

Let m be the mass of the body and mg N be the weight of the body.

Frictional force (f)= ma

=> f = 4m N

Coefficient of kinetic friction = 4m/mg = 4/g = 0.4

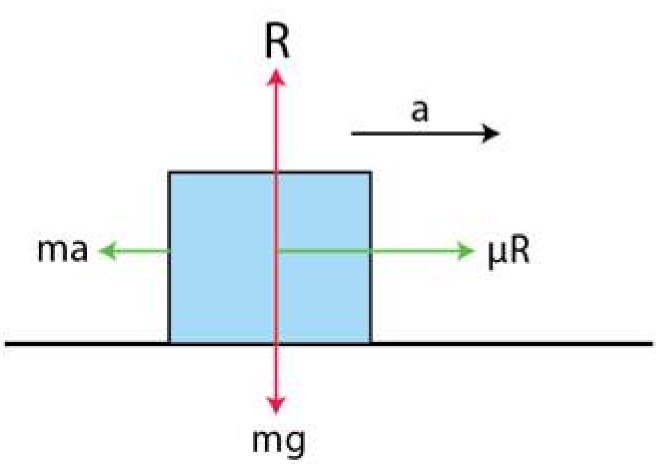
Therefore, μ= 0.4

The co-efficient of kinetic friction between the block and the plane is 0.4.

Solution 2:
Given,
Coefficient of kinetic friction = μ= 0.10
Initial velocity of the body = u = 10m/s

Let m be the mass of the body and mg N be the weight of the body

Normal force on the body N = mg



Frictional force = f= μN = 0.10 mg

Deacceleration due to kinetic friction =a =force/mass

= (0.10 mg)/m = 0.10g= 0.98 m/s^2

Final velocity due to deacceleration v= 0 m/s

Using equation, $V^2 = u^2 + 2as$, we have

$0 = 10^2 + 2(0.98)s$

=> s = 51 m
It will travel 51m before coming to rest.

Solution 3:
As the block is kept on horizonal surface and it is at rest, the frictional force will be zero. When the force is applied on the body to move it, the frictional force will act in opposite direction to oppose the motion. Hence, when body is at rest, frictional force will be zero.

Solution 4:

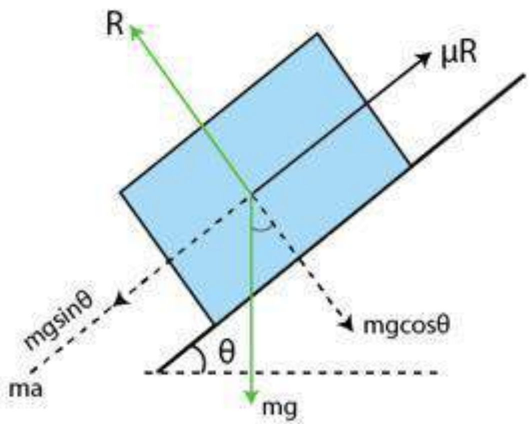
Angle of inclination= 30^o
Time taken (t)= 2 sec
Distance travelled (s) = 8m
Initial velocity of the body= 0 m/s
Let "a" be the acceleration of the body.

Using equation, $s = ut + (1/2) at^2$

=> $8 = 0 + 1/2\ a\ (2^2)$

=> a = 4 m/s^2

Now, the net force on the body = F = m.a = m (4)= 4m N



Let us consider "f" frictional force experienced by body while moving

So, the net force on the body:

= mg sin30°- f
= (1/2) mg - f

On equating the above two equations, we get

(1/2) mg - f = 4m

=> f = 0.9 m

Normal force on the body= mg cos30° = √3/2 (9.8)m= 8.48m
Coefficient of kinetic energy= 0.9m/8.48m = 0.11
Therefore, the coefficient of kinetic friction between the surfaces is 0.11,

Solution 5:
Mass of the block = m = 4kg
When no external force was applied, net force is "mgsin30° - f"

Here, external force F = 0.9m

Total net force along the inclination = mg sin30° - f + 4 N

Substituting the values,
=> 4× 9.8 × 1/2 – (0.9 × 4)+ 4 N

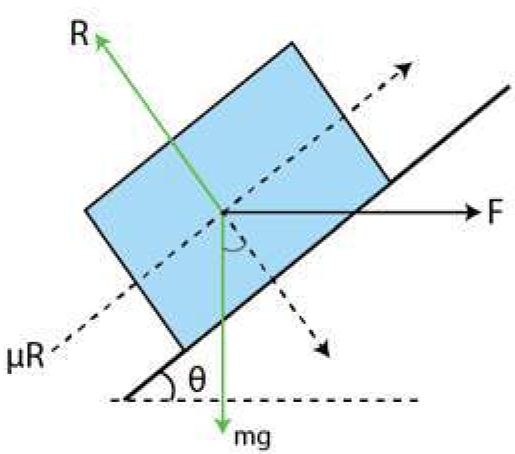
= 20 N

Hence, the acceleration of the body = a =force/mass = 20/4 = 5 m/s^2

The distance travelled in time 2 secs after starting from rest, s = ut + (1/2) at^2

=> 0 + 1/2(5)(2^2) = 10 m
The block will move 10 m.

Solution 6:
mass of the body = m = 2kg
Angle of inclination = θ = 30°
Coefficient of static friction = μ = 0.2



(a)
To make the block move up the incline, the force should be equal and opposite to the net force acting down the incline i.e. $\mu R + 2g \sin 30^o$

$= 0.2 \times 9.8\sqrt{3} + 2 \times 9.8 \times 1/2$
$= 13N$

(b)
Net force acting down the incline

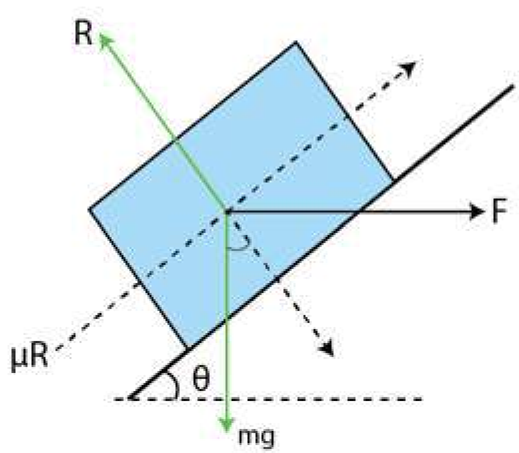
$F = 2g \sin 30^o - \mu R$

$= 2 \times 9.8 \times 1/2 - 3.39$
$= 6.41$ N

Due to force, F = 6.41 N, body will move in the incline with acceleration.
So, no external force is required. Therefore, force required is zero.

Solution 7:

mass of the body =m= 2kg
Angle of inclination =θ = 30°
Coefficient of static friction =μ = 0.2
and $g = 10$ m/s^2



from free body diagram,

$R - mg\cos\theta - F\sin\theta = 0$

or $R = mg\cos\theta + F\sin\theta$

and $mg\sin\theta - \mu R - F\cos\theta = 0$

Using value of R,
$mg\sin\theta - \mu(mg\cos\theta + F\sin\theta) - F\cos\theta = 0$

$$\Rightarrow F = \frac{mg\sin\theta + \mu mg\cos\theta}{\mu\sin\theta - \cos\theta}$$

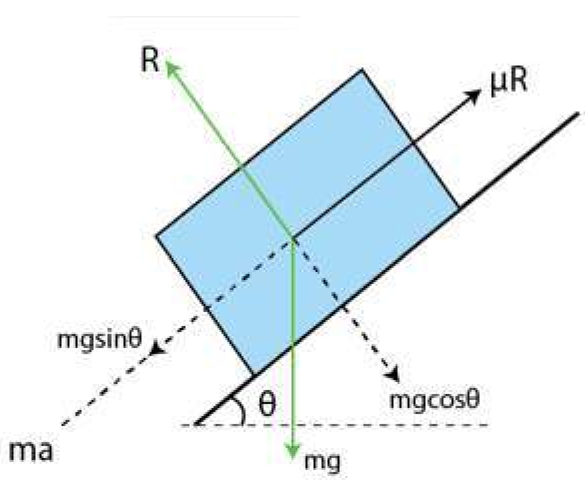
$$\Rightarrow F = \frac{2x10x\left(\frac{1}{2}\right) + 0.2x2x10x\left(\frac{\sqrt{3}}{2}\right)}{0.2x\left(\frac{1}{2}\right) - \left(\frac{\sqrt{3}}{2}\right)}$$

$$\Rightarrow F = 17.5\text{ N}$$

Solution 8:

mass of the boy= m

Angle of inclination= $\theta = 45^{o}$
Coefficient of friction = $\mu = 0.6$



$R = mg\cos(45^o) = 0$

$\Rightarrow R = mg/\sqrt{2}$
Now, The force due to which boy is sliding down is

$F = mg\sin(45^o) - \mu R$

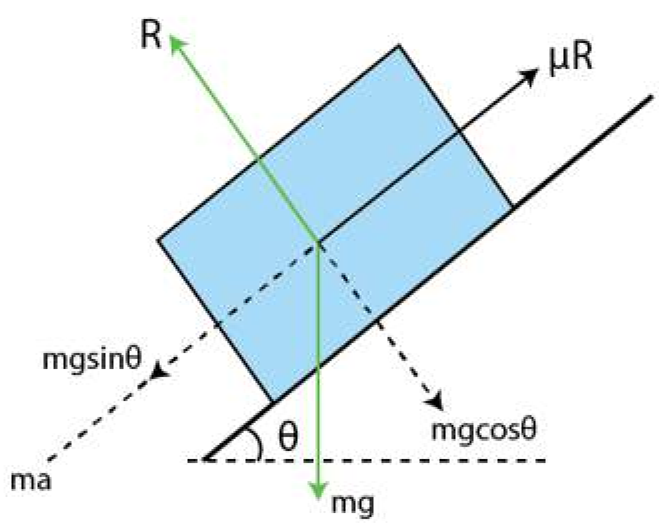
$\Rightarrow F = mg\sin(45^o) - \mu mg\cos(45^o)$

$\Rightarrow F = m(10)(1/\sqrt{2}) - 0.6\, m\, (10)(1/\sqrt{2})$
$\Rightarrow F = (2\sqrt{2})m$

Thus, Acceleration of the boy = a= force/mass = $(2\sqrt{2})m/m = (2\sqrt{2})\ m/s^2$

Solution 9:

Let us consider "m" be the mass of the boy
Angle of inclination = θ
Acceleration of the body = a



Now,
$R = mg\cos\theta$ ...(1)

and $ma = mg\sin\theta - \mu R$ ...(2)

Using (1) in (2), we have

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

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

Case 1:
In first half meter, the distance covered= s= 0.5 m

Time taken= t= 0.5sec

Initial velocity =u= 0

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

=> $(0.5) = 1/2\ (a)(1/2)^2$

=> $a = 4\ m/s^2$

case 2: For next half meter,

Velocity =u=2 m/s

Acceleration= a= 4 m/s^2

Distance =s= 0.5m

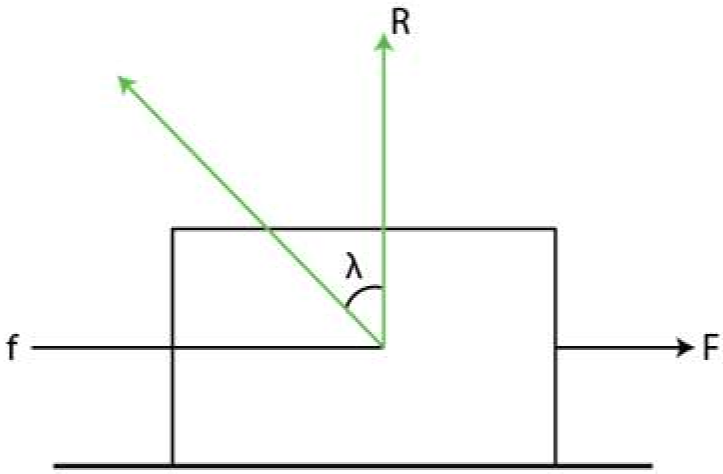
Using equation of motion, $s = ut + (1/2)\ at^2$

=> $(0.5) = 2t + (\frac{1}{2})(4)(t^2)$

=> t = 0.21 sec.

Solution 10:
Let the frictional force to be f, and F be the applied force and normal reaction be R

Now, coefficient of friction force = $\mu = \tan\lambda = f/R$



When the force applied on the body increases, the force of friction also increases. It increases up to limiting friction. Before reaching to the limiting friction,

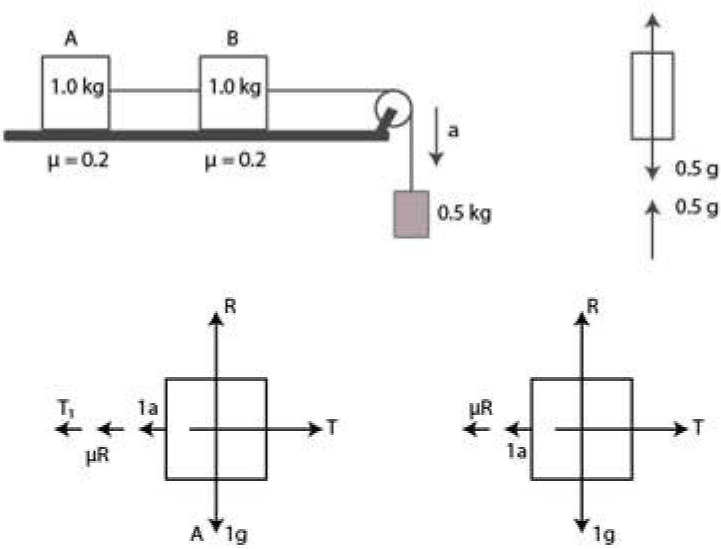
$$f < \mu R$$

$$\Rightarrow \tan\lambda = \frac{f}{R} \le \frac{\mu R}{R}$$

$$\Rightarrow \tan\lambda \le \mu$$

$$\Rightarrow \lambda \le \tan^{-1}\mu$$

Solution 11:



From the free body diagram,

$T + 0.5a - 0.5\ g = 0$ ..(1)

$\mu R + a + T_1 - T = 0$ ...(2)

$\mu R + a = T_1$ ...(3)

From equations (2) and (3

$T = 2T_1$

(2)=> $\mu R + a + T_1 - 2\ T_1 = 0$

Or $T_1 = \mu R + a = 0.2\ g + a$ ...(4)

(1)=> $2T_1 + 0.5a - 0.5g = 0$

=> $T_1 = 0.25g - 0.25\ a$ ...(5)

From equations (4) and (5)

$0.2g + a = 0.25g - 0.25a$

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

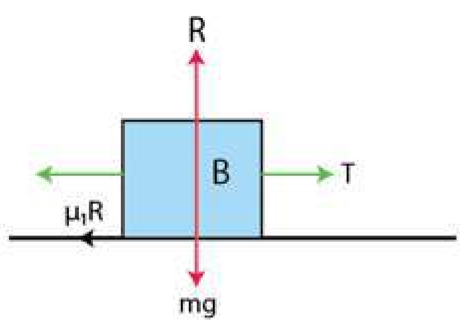
Now,

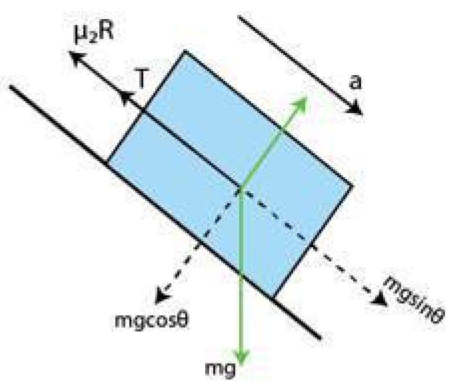
(a) acceleration of 1 kg blocks each is $0.4\ m/s^2$

(b) Tension $T_1 = 0.2g + a + 0.4 = 2.4N$

(c) Tension = $T = 0.5g - 0.5a = 4.8N$

Solution 12:





From first figure:
$\mu_1 R + ma = T$

$\mu_1 R + 2(0.5) = 16$ {Here $R = mg\cos\theta$}

$\Rightarrow \mu_1 (2g) = 15$

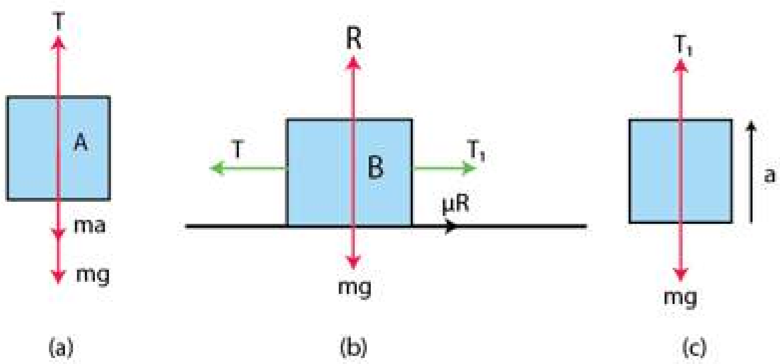
$\Rightarrow \mu_1 = 0.75$

From second figure:
$\mu_2 R + ma = F - mg\sin\theta$

$\Rightarrow \mu_2 mg\cos\theta + 4(0.5) = 16 - 4g\sin 30°$

$\Rightarrow \mu_2 = 0.06$

Solution 13:



Let us consider that the 15kg block is moving downward with the acceleration a.

Case 1: From figure (a)

$T + ma - mg = 0$

$T + 15a - 15g = 0$

$\Rightarrow T = 15g - 15a$....... (1)

Case 2: From the figure (c)

$T_1 - mg - ma = 0$

$T_1 - 5g - 5a = 0$

$\Rightarrow T_1 = 5g + 5a$ .... (2)

Case 3: From figure (b)

$T = (T_1 + 5a + \mu R) = 0$

$\Rightarrow T - (5g + 5a + 5a + \mu R) = 0$ ……. (3)

(where $R = \mu g$)

From Equations (1) and (2),
$15g - 15a = 5g + 10a + 0.2\ (5g)$
$\Rightarrow 25a = 90$

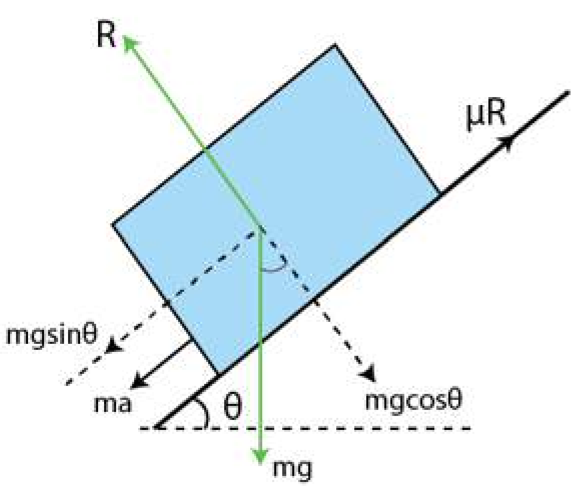
$\Rightarrow a = 3.6\ m/s^2$

From Equation (3),
$T = 5 \times 10 + 10 \times 3.6 + 0.2 \times 5 \times 10$

T= 96 N in the left string.

From Equation (2),
$T_1 = 5g + 5a$
$= 5 \times 10 + 5 \times 36 = 50 + 18 T_1 = 68$ N in the right string.

Solution 14:



Let θ the maximum angle of incline.
distance travel s = 5 m,
Initial velocity of the vehicle= u = 36 km/h = 10 m/s
Final velocity of the vehicle= v = 0
and μ=4/3, g = 10 m/s^2

Now, $V^2 - u^2 = 2as$

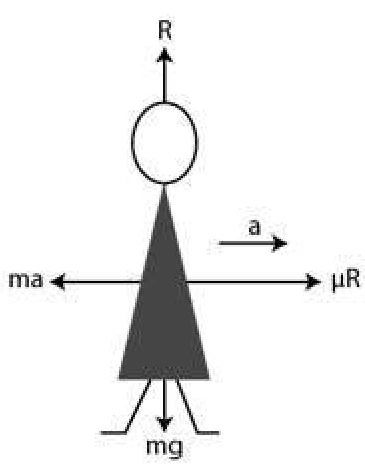
r a = -10 m/s^2

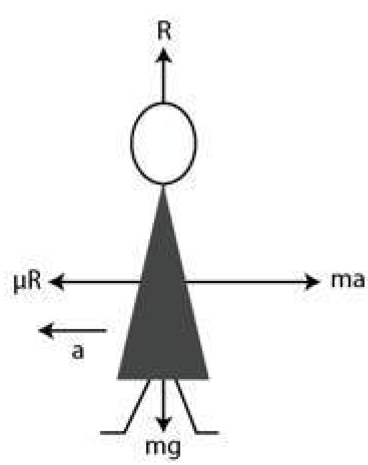
From the free body diagram
R = mg cosθ
Again, ma + mg sinθ = μR
=> ma + mg sinθ = μmg cosθ
=> a + g sinθ = μg cosθ
=> 10 +10 sinθ = 4/3×10 cosθ
=> 4 cosθ − 3 sin θ = 3
=> $4(1-\sin^2 \theta)^{1/2} = 3 + 3 \sin\theta$
=> $16 (1 - \sin^2 \theta) = 9 + 9 \sin^2 \theta + 18 \sin\theta$
=> $25 \sin^2 \theta + 18 \sin\theta - 7 = 0$

or sinθ = 0.28
or θ = 16°

Maximum incline is θ = 16°

Solution 15:





Superman has to move with maximum possible acceleration, to reach the given distance in minimum time,

Let us consider "a" be the maximum acceleration.
So, $ma - \mu R = 0$

=> $ma = \mu mg$
=> $a = \mu g = 0.9 \times 10 = 9 \ m/s^2$

(a)
In this case,
initial velocity =u = 0,
t = ?
acceleration =a = $9 \ m/s^2$,
distance s = 50 m

From the equation of motion, $s = ut + (1/2) at^2$

$50 = 0 + 1/2 \times 9t^2$

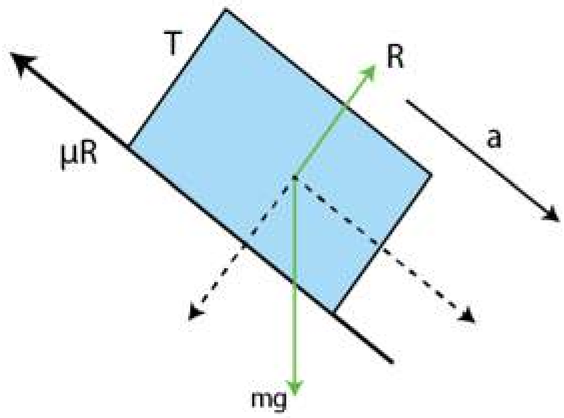
or t = 10/3 sec

(b)
After covering 50 m, the velocity of the athlete
v = u + at
=0+9×103 m/s

=30 m/s
He has to stop in minimum time. Hence, the deceleration,
$a = -9 \ m/s^2$ (max)
R = mg
$ma = \mu R$ (maximum frictional force)
$ma = \mu mg$
$\Rightarrow a = \mu g$
$= 9 \ m/s^2$ (deceleration)
$u_1 = 30$ m/s, v = 0
=> $t = (v_1 - u_1)/a$

or t = 10/3 sec.

Solution 16:



Hardest brake means maximum force of friction is produced between car's type and road.
maximum frictional force = μR

$R - mg\cos\theta = 0$
$\Rightarrow R = mg\cos\theta$ (i)
And $\mu R + ma - mg\sin\theta = 0$ (ii)
$\Rightarrow \mu\, mg\cos\theta + ma - mg\sin\theta = 0$

$\Rightarrow \mu g\cos\theta + a - 10(12) = 0$

$\Rightarrow a = 5 - \{1-(2\surd 3)\} \times 10(\surd 3/2)$

or $a = -2.5\ m/s^2$

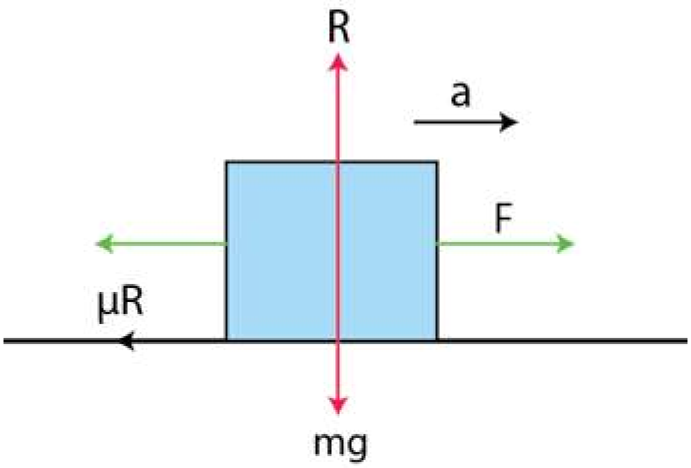
When brakes are applied, car will deaccelerate by $2.5\ m/s^2$

Distance =s= 12.8 m
initial velocity= u = 6 m/s
∴ Velocity at the end of incline

$v = \surd(u^2+2as) = \surd(36+2(2.5)(12.8) = 36$ km/h

Hence how hard the driver applies the breaks, car reaches the bottom with least velocity 36 km/h.

Solution 17:



From diagram,

$ma = \mu R$

$ma = \mu mg$

$a = \mu g = 1 \times 10 = 10 \text{ m/s}^2$

To cross the bridge in minimum time, it must be at its maximum acceleration.

here, initial velocity u = 0, acceleration $a = 10 \text{ m/s}^2$ and Distance s = 500 m,

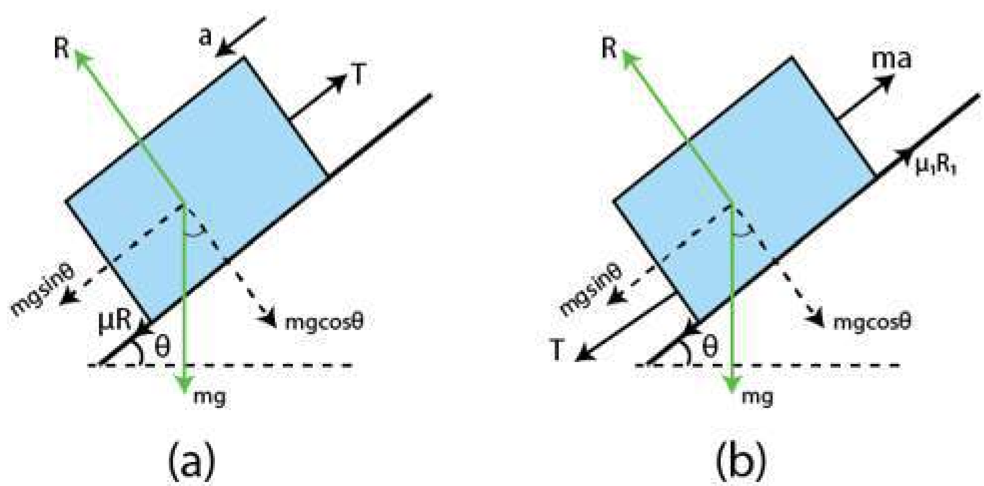
From equation $s = ut + 1/2\ at^2$

$500 = 1/2 \times 10 \times 10^2$

or t = 10 sec

car will take more than 10 sec to cross the bridge if the acceleration is less than 10 m/s^2.

Solution 18:



Angle of inclination = $\theta = 30^o$

The free body diagram of the system is shown above

From the figure (a), mass = 4kg

$R = 4g \cos 30°$
$\Rightarrow R = 20\sqrt{3}$ N ...(1)
and
$\mu_2 R + ma = T + mg \sin\theta$
$\mu_2 R + 4a = T + 4g \sin 30°$
$\Rightarrow 0.3\times(40)\cos 30° + 4a = T + 40 \sin 30°$ ....(2)

From the figure (a), mass = 2kg

$R_1 = 2g \cos 30°$
$=10/\sqrt{3}$ ..... (3)
$T + 2a - \mu_1 R_1 - 2g \sin 30° = 0$ .....(4)

From Equation (2),
$6\sqrt{3} + 4a - T - 20 = 0$

From Equation (4),

$T + 2a + 2\sqrt{3} - 10 = 0$

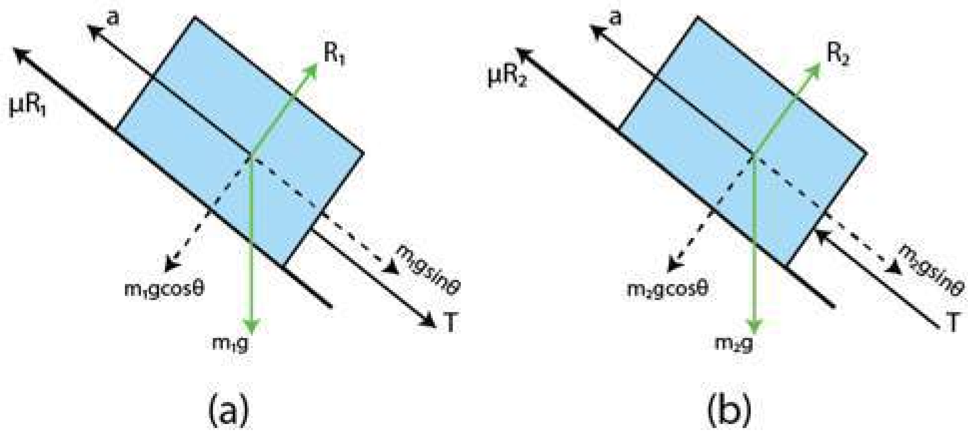
From equation (2) and (4)
$6\sqrt{3} + 6a - 30 + 2\sqrt{3} = 0$

$\Rightarrow 6a = 30 - 8\sqrt{3}$

$\Rightarrow a = 2.7 \text{ m/s}^2$

(b) 4 kg block will move at a higher acceleration because the coefficient of friction is less than that of the 2 kg block. Therefore, the two blocks will move separately. By drawing the free body diagram of 2 kg mass, it can be shown that $a = 2.4 \text{ m/s}^2$.

Solution 19:



$R_1 = m_1 g \cos\theta$

$T + m_1 \sin\theta = m_1 a + \mu R_1$

$T + m_1 g \sin\theta = m_1 a + \mu m_1 g \cos\theta$ ..... (i)

From figure (b)
$R_2 = m_2 g \cos\theta$
$T - m_2 g \sin\theta = m_2 a - \mu R_2$

$T - m_2 g \sin\theta + m_2 a + \mu m_2 g \cos\theta = 0$ ....(ii)

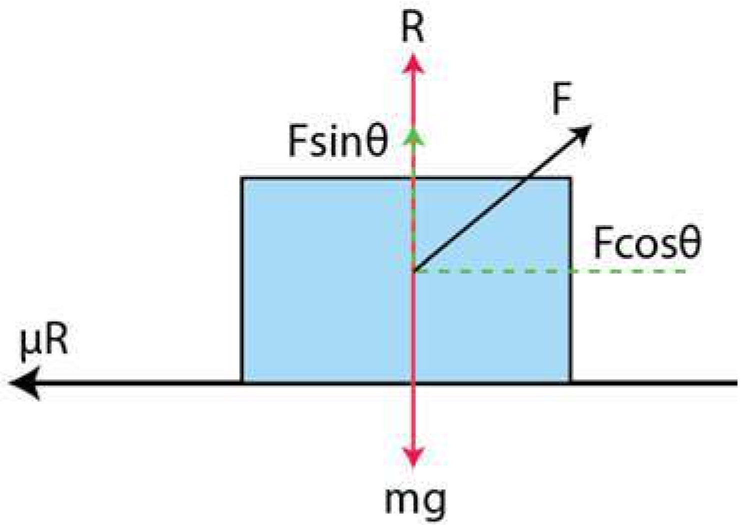
From Equations (i) and (ii),
$g \sin\theta(m_1 + m_2) - a(m_1 + m_2) - \mu g \cos\theta(m_1 + m_2) = 0$

=> $a = g(\sin\theta - \mu \cos\theta)$
Hence, the acceleration of the system = $g(\sin\theta - \mu\cos\theta)$

The force exerted by the rod on one of the blocks is tension, T.
$T = m_1 g \sin\theta + m_1 a + \mu m_1 g \cos\theta$
$T = - m_1 g \sin\theta + m_1(g \sin\theta - \mu g \cos\theta) + \mu m_1 g \cos\theta = 0$

=> $T=0$

Solution 20:



From the free body diagram,
$R + F \sin\theta = mg$
$\Rightarrow R = -F \sin\theta + mg$ ...(1)
$\mu R = F \cos\theta$ .....(2)

From Equation (1),
$\mu(mg - F\sin\theta) - F\cos\theta = 0$
$\Rightarrow \mu mg = \mu F \sin\theta + F\cos\theta$

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

F should be minimum, when $\mu \sin\theta + \cos\theta$ is maximum.
Again, $\mu \sin\theta + \cos\theta$ is maximum when its derivative is zero:

$d/d\theta\ (\mu\sin\theta + \cos\theta) = 0$

$\Rightarrow \mu \cos\theta - \sin\theta = 0$
$\theta = \tan^{-1}\mu$
So,

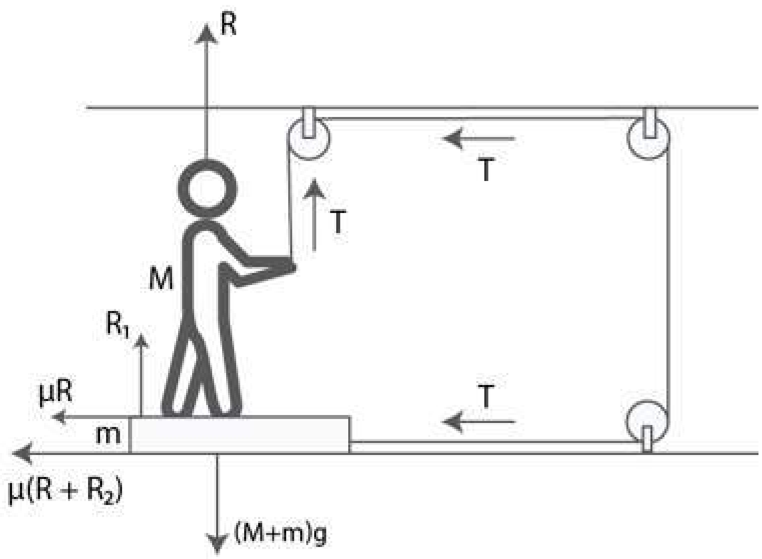
$$F = \frac{\mu mg}{\mu \sin\theta + \cos\theta}$$

$$F = \frac{\mu mg \cos\theta}{1 + \mu \tan\theta} = \frac{\mu mg \sec\theta}{1 + tan^2\theta}$$

$$F = \frac{\mu mg}{\sec\theta} = \frac{\mu mg}{\sqrt{1 + tan^2\theta}} = \frac{\mu mg}{\sqrt{1 + \mu^2}}$$

Minimum force required is μmg/√(1+μ^2)

Solution 21:



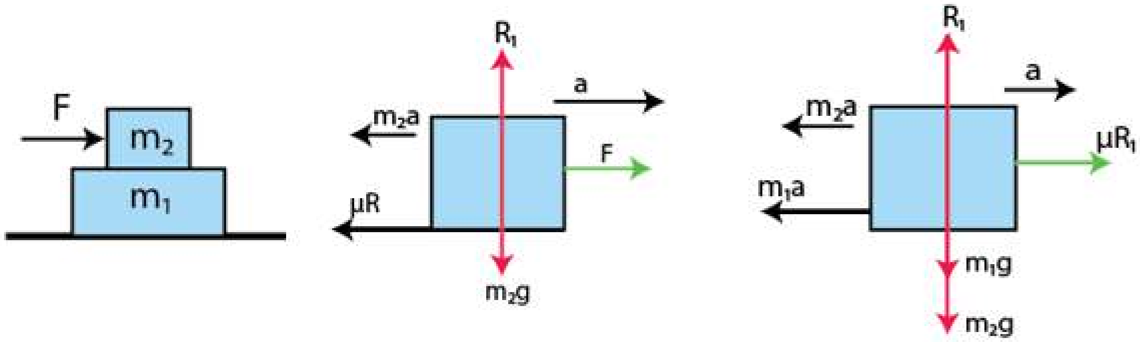
$R + T = Mg$
$\Rightarrow R = Mg - T$ ....(1)
Also, $R_1 - R - mg = 0$
$\Rightarrow R_1 = R + mg$ .....(2)
And $T - \mu R_1 = 0$

From Equation (2),
$T - \mu(R + mg) = 0$
$\Rightarrow T - \mu R - \mu\, mg = 0$
$\Rightarrow T - \mu(Mg - T) - \mu mg = 0$
$T - \mu Mg + \mu t - \mu mg = 0$

$\Rightarrow T\,(1 + \mu) = \mu Mg + \mu mg$

=> T = (μ(M+m)g)/(1+μ), which is the maximum force exerted by the man.

Solution 22:



for the mass of 2 kg m_2

$R_1 - 2g = 0$
$\Rightarrow R_1 = 2 \times 10 = 20$
$2a + 0.2\ R_1 - 12 = 0$
$\Rightarrow 2a + 0.2\ (20) = 12$
$\Rightarrow 2a = 12 - 4$
$\Rightarrow a = 4\ m/s^2$

for 4kg block mass m_1

$4a - \mu R_1 = 0$
$\Rightarrow 4a = \mu R_1 = 0.2\ (20) = 4$
$\Rightarrow a = 1\ m/s^2$

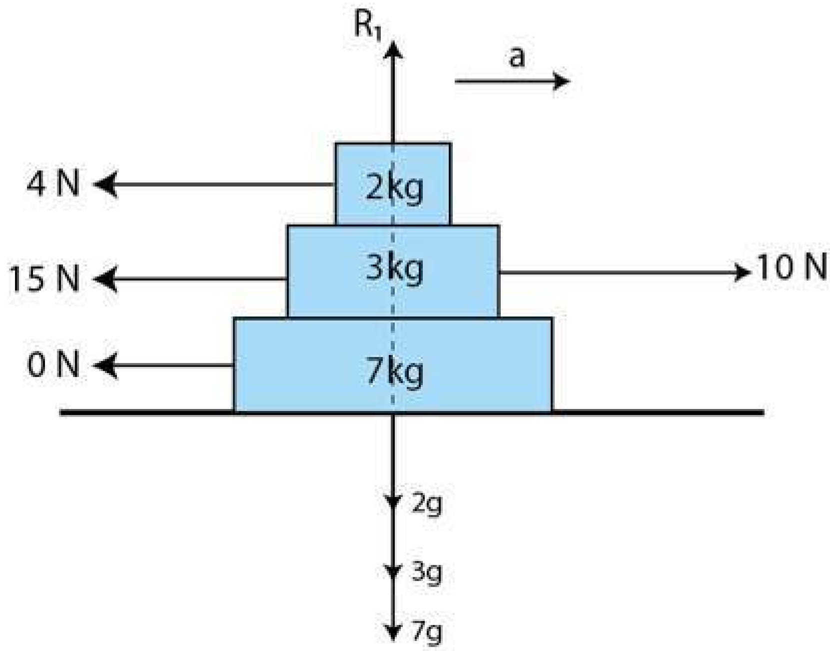
The 2 kg block has acceleration 4 m/s^2 and the 4 kg block has acceleration 1 m/s^2.

we can also write,

$R_1 = 2g = 20$
$Ma = \mu R_1 = 0$
$a = 0$

and
$Ma + \mu mg - F = 0$
$4a + 0.2 \times 2 \times 10 - 12 = 0$
$\Rightarrow 4a + 4 = 12$
$\Rightarrow 4a = 8$
$\Rightarrow a = 2\ m/s^2$

Solution 23:



The coefficient of frictions are given as, $\mu_1 = 0.2$, $\mu_2 = 0.3$ and $\mu_3 = 0.4$

(a) When the 10 N force is applied to the 2 kg block, it experiences maximum frictional force.

Here,$\mu_1 R_1 = \mu_1 \times m_1 g$

$\mu_1 R_1 = \mu_1 \times 2g$

$= (0.2) \times 20$

= 4 N (From the 3 kg block)

The net force experienced by the 2 kg block = 10 – 4 = 6 N

Hence, $a_1 = 6/2 = 3\ m/s^2$

In this case, the frictional force from the 2 kg block becomes the driving force (4N) and the maximum frictional force between the 3 kg and 7 kg blocks.

so, $\mu_2 R_2 = \mu_2 m_2 g = (0.3) \times 5$ kg = 15 N

3 kg block cannot move relative to the 7 kg block, because there is no friction from the floor.

So, $a_2 = a_3 = 4/10 = 0.4\ m/s^2$

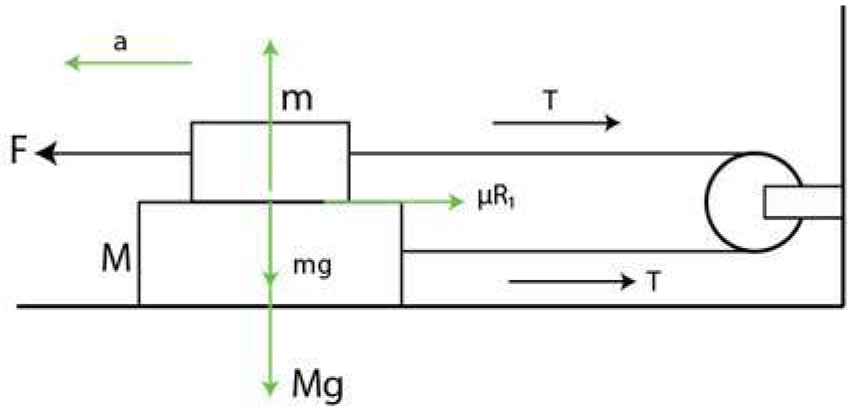
(b) When the 10 N force is applied to the 3 kg block, it experiences maximum frictional force of 19 N, from 2 kg and 7 kg block. As the floor is frictionless, all the three bodies will move together.

$a = 10/12 = 5/6\ m/s^2$

(c) when 10 N force is applied to the 7 kg block, all three blocks will move together with the same acceleration.

Hence, $a_1 = a_2 = a_3 = 5/6\ m/s^2$

Solution 24:



(a) $R_1 = mg$ ...(i)

$F = \mu R_1 + T$ ...(ii)

$T - \mu R_1 = 0$ ..(iii)

From equations (i) and (ii)

$F - \mu mg = T$ ...(ii)

From equations (i) and (iii)

$T = \mu mg$

Putting $T = \mu mg$ in equation (ii)

$F = \mu mg + \mu mg = 2\mu mg$

(b)

From upper block of free body, we have

$2F - T - \mu mg = ma$

From lower block of free body, we have

$T = Ma + \mu mg$

Equating both the equations,

$2F - Ma - \mu mg - \mu mg = ma$

Putting $F = 2\mu mg$, we get

$2(2\mu mg) - 2\mu mg = a(M + m) \Rightarrow 4\mu mg - 2\mu mg = a(M + m)$

=> $a = 2\mu mg/(M+m)$ in opposite directions.

Solution 25:

Referring Question 24 image.

(a)
$R_1 + ma - mg = 0$
$\Rightarrow R_1 = m(g - a)$
$= mg - ma$

Now, $F - T - \mu R_1 = 0$ and
$T - \mu R_1 = 0$
$\Rightarrow F - [\mu(mg - ma)] - \mu(mg - ma) = 0$
$\Rightarrow F - \mu mg - \mu ma - \mu mg + \mu ma = 0$
$\Rightarrow F = 2\mu mg - 2\mu ma$
$= 2\mu m(g - a)$

(b) Let a_1 be acceleration of the blocks, then

$R_1 = mg - ma$ ....(i)
$2F - T - \mu R_1 = ma_1$ ...(ii)
Now, $T = \mu R_1 + Ma_1$
$= \mu mg - \mu ma + Ma_1$

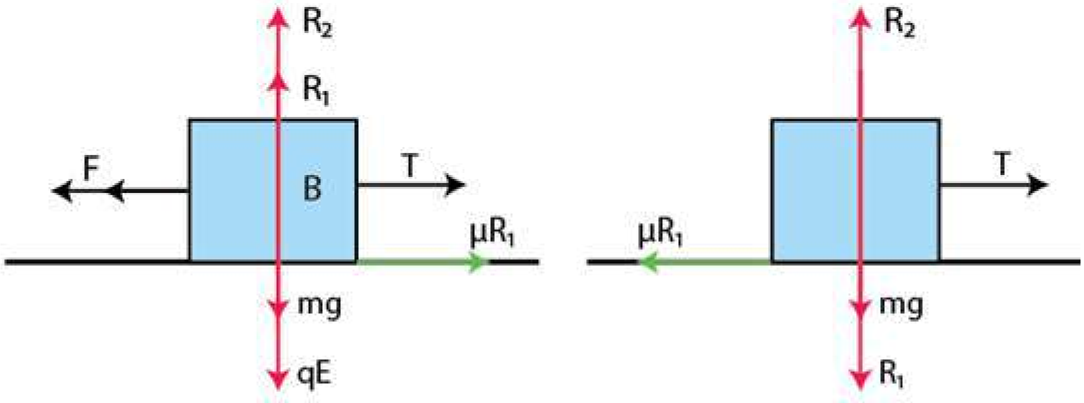
Substituting the value of F and T in equation (ii),
$2[2\mu m(g - a)] - (\mu mg - \mu ma + Ma_1) - \mu mg + \mu ma = ma_1$
$\Rightarrow 4\mu mg - 4\mu ma - 2\mu mg + 2\mu ma = ma_1 + Ma_1$

=>

$$a_1 = \frac{2\mu m(g - a)}{m + M}$$

Both the blocks move with same acceleration a_1 but in opposite directions.

Solution 26:



R_1 is the normal reaction force
E is the small electric field
Q is the charge
From the figure (b)
$R_1 + qE = mg$

$\Rightarrow R_1 = mg - qE$ ...(1)

From figure (a)

$F - T - \mu R_1 = 0$

$\Rightarrow F - T - \mu mg + \mu qE = 0$ ....(2)
[Using (1)]

Again from (1) and (2)

$T - \mu R_1 = 0$

$\Rightarrow T - \mu R_1 = \mu(mg - qE) = \mu mg - \mu qE$
From (2),

$F - \mu mg + \mu qE - \mu mg + \mu qE = 0$

$\Rightarrow F = 2\mu(mg - qE)$
Which is the maximum horizontal force applied.

Solution 27:

When the body is slipping from the surface, the maximum frictional force is acting on it.

$R = mg$

$F - \mu R = 0$

$\Rightarrow F = \mu R = \mu mg$

As, table is at rest, the frictional force at table's legs will also be μR. Let the frictional force be f,

$f - \mu R = 0$

$\Rightarrow f = \mu R = \mu mg$

Therefore, the total frictional force on the table by the floor is μmg.

Solution 28:

Let the acceleration of block of mass M is 'a' towards right. So, the block 'm' must go down with an acceleration '2a'. As the block 'm' is in contact with the block 'M', it will also have acceleration 'a' towards right.

$R_1 - ma = 0$

$\Rightarrow R_1 = ma$ ....(i)

Also,

$2ma + T - Mg + \mu_1 R_1 = 0$

$\Rightarrow T = Mg - (2 + \mu_1)\ ma$ .....(ii)

Also, $T + \mu_1 R_1 + Mg - R_2 = 0$

using (i), $R_2 = T + \mu_1\ ma + mg$

again using value of T from (2), we get

$R_2 = Mg + Ma - 2ma$ ...(iii)

Again, from figure we have

$T + T - R - Ma - \mu_2 R_2 = 0$

$\Rightarrow 2T - Ma - ma - \mu_2(Mg + mg - 2ma) = 0$

Substituting the values of R_1 and R_2 from (i) and (iii), we get:

$2T = (M + m)a + \mu_2\ (Mg + mg - 2ma)$ ....(iv)

From equations (ii) and (iv), we have:

$\Rightarrow 2mg - \mu_2 (M + m)g = a[M + m - 2\mu_2 m + 4m + 2\mu_1 m]$

Thus, acceleration of the block of mass M is

$$a = \frac{2m + \mu 2(M+m)g}{M+m(5+2(\mu 1-\mu 2))}$$

Solution 29:
Net force on the block = $(20)^2 + (15)^2 - 0.5 \times 40 = 5$ N

Therefore, $\tan \theta = 20/15 = 4/3$

or, $\theta = \tan^{-1} (4/3) = 53°$

The block will move at 53° angle with the 15 N force.

Solution 30:

Mass of man = 50 kg and g = 10 m/s^2

Frictional force developed between hands, legs & back with the wall will be equal to the weight of the man. Man remains in equilibrium.
If man applies unequal forces on the wall, the reaction force will be different and he can't rest between the walls. Frictional force $2\mu R$ balance his body weight.

$\mu R + \mu R = mg$
$\Rightarrow 2\mu R = 40 \times 10$

$\Rightarrow R = 40 \times 10/2 \times 0.8 = 250$ N, Which is normal force.

Solution 31:
Let masses m and M are having acceleration a_1 and a_2 respectively.

if $a_1 > a_2$ so, mass m can move on mass M.
Also, consider after time 't', the mass m separates from mass M
During this time, mass m covers the distance s,
$s = vt + 1/2\, a_1 t^2$

and $s\_m = ut + 1/2\, a_2\, t^2$

For mass m to separate from mass M,

$vt + 1/2\ a_1t^2 = vt + 1/2\ a_2t^2$ .....(1)

$ma_1 + (1/2)\mu R = 0$

$ma_1 = -(1/2)\mu mg = (1/2)\mu m \times 10$

$a_1 = -5\mu$

Again, from figure, $Ma_2+\mu(M+m)\ g-(\mu/2)\ mg = 0$

$2Ma_2 = \mu mg - 2\mu mg - 2\mu mg$

$\Rightarrow a_2 = (-\mu mg - 2\mu Mg)/2M$

Substituting the values of a_1 and a_2 in equation (1), we get:

$t = \sqrt{[(4ml)/(M+m)\mu g]}$