SOLVED EXAMPLES

Ex.1 An astronaut accidentally gets separated out of his small spaceship accelerating in inter-stellar space at a constant acceleration of 10 m/s^2. What is the acceleration of the astronaut at the instant he is outside the spaceship ?

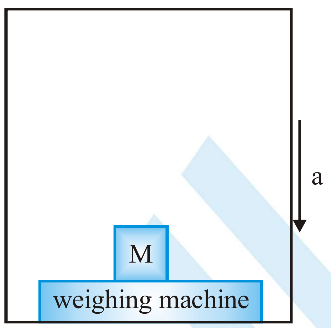
(A) 10 m/s^2 **(B)** 9.8 m/s^2

(C) $\approx$ 0 m/s^2 **(D)** could be anything

Ans. **(C)**

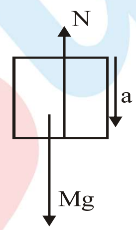
Sol. When the astronaut is outside the spaceship, the net external force (except negligible gravitational force due to spaceship) is zero as he is isolated from all interactions.

Ex.2 With what acceleration 'a' shown the elevator descends so that the block of mass M exerts a force of $\frac{Mg}{10}$ on the weighing machine ? [g = acceleration due to gravity]

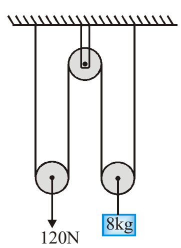


(A) 0.3 g **(B)** 0.1 g **(C)** 0.9g **(D)** 0.6 g

Sol. FBD of block : $Mg - N = Ma$; Now according to question $N = \frac{Mg}{10}$ so $a = \frac{Mg - \frac{Mg}{10}}{M} = 0.9g$

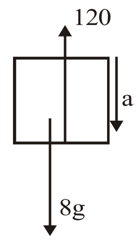


Ex.3 If the string is pulled down with a force of 120 N as shown in the figure, then the acceleration of 8 kg block would

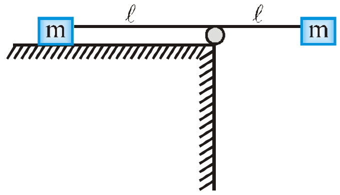


(A) 10 m/s^2 **(B)** 5 m/s^2 **(C)** 0 m/s^2 **(D)** 4 m/s^2

Sol. FBD of 8 kg block $a = \frac{120 - 80}{8} = 5 m/s^2$



Ex.4 As shown in figure, the left block rests on a table at distance ● from the edge while the right block is kept at the same level so that thread is unstretched and does not sag and then released. What will happen first ?



(A) Left block reach the edge of the table
(B) Right block hit the table
(C) Both (A) and (B) happens at the same time
(D) Can't say anything

Sol. Net force in horizontal direction is more for left block so it will reach the edge of the table first.

Ex.5 In the shown situation, which of the following is/are possible ?

(A) Spring force = 52 N, if $F_1 = 40$ and $F_2 = 60$ N
(B) Spring force = 52 N, if $F_1 = 60$ and $F_2 = 40$ N
(C) Spring force = 0, if $F_1 = F_2 = 100$ N
(D) Spring force $\neq 0$, if $F_1 = 0.2$ N and $F_2 = 0.3$ N

Sol. If $F_1 \neq F_2$, then system will move with acceleration so spring force $\neq 0$

If $F_1 = 40$ N & $F_2 = 60$ N then $a = \dfrac{F_2 - F_1}{m_1 + m_2} = \dfrac{20}{100} = \dfrac{1}{5}\, m/s^2$ and spring force $F_1 + m_1 a = 40 + \dfrac{1}{5}(60) = 52$ N

If $F_1 = 60$ N & $F_2 = 40$ N then spring force = 52 N

Ex.6 The force exerted by the floor of an elevator on the foot of a person standing there is less than the weight of the person if the elevator is

(A) going up and slowing down
(B) going up and speeding up
(C) going down and slowing down
(D) going down and speeding up

Ans **(A, D)**

Sol. If $N < mg$ then $N = m(g-a) \Rightarrow$ elevator is going down with acceleration or elevator is going up with retardation.

Ex.7 If a body is placed on a rough inclined plane, the nature of forces acting on the body is/are

(A) gravitational
(B) electromagnetic
(C) nuclear
(D) weak

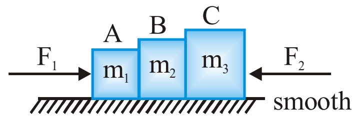
Sol. When a body is placed on a rough inclined plane, it is acted upon by a reactional force due to plane [electromagnetic in nature], a frictional force due to roughness of plane [electromagnetic in nature] and a gravitational force (due to its weight).

Ex.8 For shown situation let

N_1 = Normal reaction between A & B

N_2 = Normal reaction between B & C

Which of the following statement(s) is/are correct ?



(A) If $F_1 > F_2$ then $N_1 \neq N_2$ and $F_2 < \sqrt{N_1N_2} < F_1$ **(B)** If $F_1 < F_2$ then $N_2 > N_1$

(C) If $F_1 = F_2$ then $N_1 = N_2$ **(D)** If $F_1 = F_2$ then $N_1 \neq N_2$

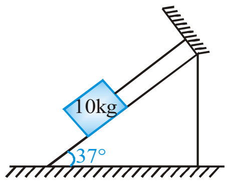
Sol. If $F_1 > F_2$, the system moves towards right so $N_1 < F_1$, $N_2 < N_1$ & $F_2 < N_2$

$$F_2 < N_1 \text{ or } N_2 < F_1$$

If $F_1 < F_2$, the system moves towards left so $N_1 < N_2$

If $F_1 = F_2$, the system does not move

Ex.9 A body of mass 10 kg is placed on a smooth inclined plane as shown in figure. The inclined plane is moved with a horizontal acceleration a.



(i) The normal reaction between block and inclined plane is :

(A) 92 N **(B)** 44 N **(C)** 56 N **(D)** Can't be determined

(ii) The tension in thread is :

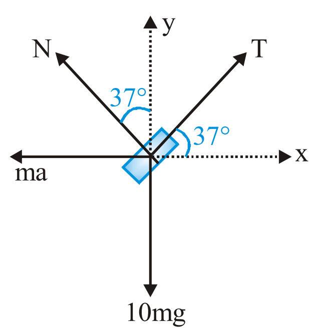
(A) 92 N **(B)** 44 N **(C)** 56 N **(D)** Can't be determined

(iii) At what acceleration 'a' will the body lose contact with the inclined plane ?

(A) 10 m/s² **(B)** 13.33 m/s² **(C)** 3.33 m/s² **(D)** 6.66 m/s²

Sol.

(i) FBD of block w.r.t. inclined plane



$\Sigma F_x = 0$ $\Rightarrow$ $T \cos 37^0 - N \sin 37^0 - ma = 0$

$\Rightarrow$ $4T - 3N = 200$ .... **(i)**

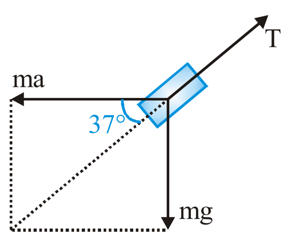
$\Sigma F_y = 0$ $\Rightarrow$ $N \cos 37^0 + T \sin 37^0 - 10\,g = 0$

$\Rightarrow$ $4N + 3T = 500$ .... **(ii)**

By solving equation **(i)** & **(ii)**, N = 56 newton

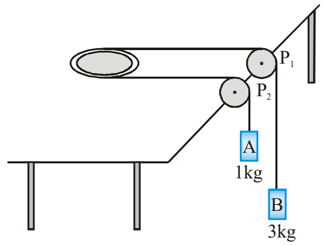
(ii) From above equation, T = 92 newton

(iii) To lose contact, N = 0



$$\tan 37^0 = \frac{mg}{ma} \Rightarrow \frac{3}{4} = \frac{10}{9} \Rightarrow a = \frac{40}{3} = 13.33 \text{ n/s}^2$$

Ex.10 A smooth pulley P_0 of mass 2 kg is lying on a smooth table. A light string passes round the pulley and has masses 1 kg and 3 kg attached to its ends. The two portions of the string being perpendicular to the edge of the table so that the masses hang vertically. Pulleys P_1 and P_2 are of negligible mass. [g = 10 m/s²]



(i) Tension in string is

(A) 12 N **(B)** 6 N **(C)** 24 N **(D)** 18 N

(ii) Acceleration of pulley P_0 is

(A) 2 m/s^2 **(B)** 4 m/s^2 **(C)** 3 m/s^2 **(D)** 6 m/s^2

(iii) Acceleration of block A is

(A) 6 m/s^2 **(B)** 4 m/s^2 **(C)** 3 m/s^2 **(D)** 8 m/s^2

Sol.

(i) Let acceleration of $P_0 = a_0$. acceleration of A = a_1, acceleration of B = a_2

By constraint relations $a_0 = \frac{a_1 + a_2}{2}$ .... **(i)**

Now for pulley $P_0 : 2T = 2a_0$ $\Rightarrow$ $T = a_0$ .... **(ii)**

For block A : $1\,g - T = 1(a_1)$ $\Rightarrow$ $10 - T = a_1$ .... (iii)

For block B : $3g - T = 3(a_2)$ $\Rightarrow$ $30 - T = 3a_2$ .... (iv)

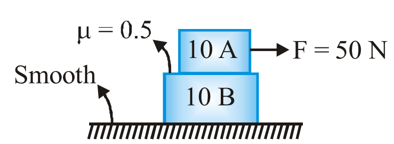
By putting the values of a_0, a_1 & a_2 in equation **(i)**

$$T = \frac{(10 - T) + \left(10 - \frac{T}{3}\right)}{2} \Rightarrow T = 6\text{ N}$$

(ii) Acceleration of pulley ; a0 = T = 6m/s2

(iii) Acceleration of block A ; a1 = 10 – T = 10 – 6 = 4 m/s^2

Ex.11 Find the acceleration of the two blocks. The system is initially at rest and the friction coefficient are as shown in the figure ?



Sol. **Method of solving**

Step 1 Make force diagram.

Step 2 Show static friction force by f because value of friction is not known.

Step 3 Calculate separately for two cases.

Case 1 : Move together

Step 4 Calculate acceleration

Step 5 Check value of friction for above case.

Step 6 If required friction is less than available it means they will move together else move separately.

Step 7 (A) Above acceleration will be common acceleration for both

Case 2 : Move separately

Step 7 (B) If they move separately then kinetic friction is involved. Whose value is μN.

Step 8 Calculate acceleration for above case.

$f_{max} = \mu N$

$\therefore$ $f \le 50$ N (available friction)

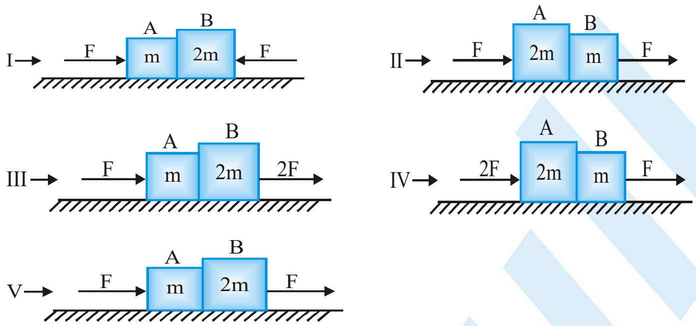
	Move together	**Move separately**
(i)	$a = \dfrac{50}{10+10} = 2.5\ m/s^2$	No need to calculate
(ii)	Check friction for B	

$f = 10 \times 2.5 = 25$

25 N is required which is less then available

friction hence they will move together. and $a_A = a_B = 2.5\ m/s^2$

Ex.12 Five situations are given in the figure (All surfaces are smooth)



	Column I		**Column II**
(A)	Acceleration of A & B are same	**(P)**	I
(B)	Acceleration of A & B are different	**(Q)**	II
(C)	Normal reaction between A & B is zero	**(R)**	III
(D)	Normal reaction between A & B is non zero	**(S)**	IV
		(T)	V

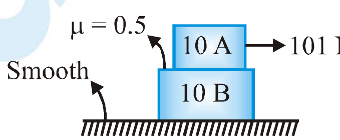
Sol. **(A) → (P, R, S, T) ; (B) → (Q) ; (C) → (Q, R, S) ; (D) → (P, T)**

$I : a_A = a_B = 0 \ \& \ N \ne 0$ $\qquad$ $II : a_A = \dfrac{F}{2m},\ a_B = \dfrac{F}{m} \ \& \ N = 0$

$III : a_A = \dfrac{F}{m},\ a_B = \dfrac{2F}{2m} = \dfrac{F}{m} \ \& \ N = 0$ $\qquad$ $IV : a_A = \dfrac{2F}{2m} = \dfrac{F}{m},\ a_B = \dfrac{F}{m} \ \& \ N = 0$

$V : a_A = a_B = \dfrac{2F}{3m} \ \& \ N \ne 0$

Ex.13 Find the acceleration of the two blocks. The system is initially at rest and the friction coefficient are as shown in the figure ?

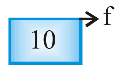


Sol. $f_{max} = 50$ N

$\therefore$ $f \le 50$ N

(i) If they move together $a = \frac{101}{20} = 5.05\ m/s^2$

(ii) Check friction on B

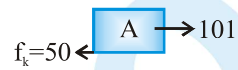


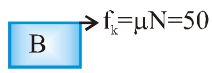
$f = 10 \times 5.05 = 50.5$ (required)

$50.5 > 50$ (therefore required > available)

Hence they will <u>not</u> move together.

(iii) Hence they move separately so kinetic friction is involved.

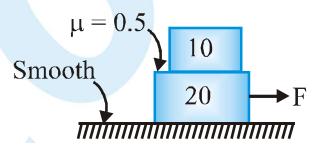




$\Rightarrow$ for $a_A = \frac{101-50}{10} = 5.1\ m/s^2$ $\Rightarrow$ $a_B = \frac{50}{10} = 5\ m/s^2$

Also $a_A > a_B$ as force is applied on A.

Ex.14 Initially the system is at rest. Find out minimum value of F for which sliding starts between the two blocks.



Sol. At just sliding condition limiting friction is acting.

$F - 50 = 20\,a$ .... **(1)**

$f = 10\,a$ .... **(2)**

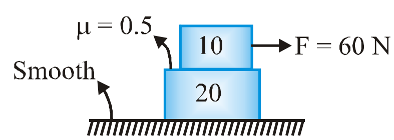
$50 = 10\,a$

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

hence $F = 50 + 20 \times 5 = 150$ N

$\therefore$ $F_{min} = 150$ N

Ex.15 Find the acceleration of the two blocks. The system is initially at rest and the friction coefficient are as shown in the figure ?



Sol.

Move Together	**Move Separately**
$a = \frac{60}{30} = 2\ m/s^2$	No need to calculate

Check friction on 20 kg

$f = 20 \times 2$

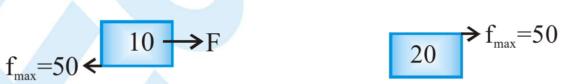
$f = 40$ (which is required)

$40 < 50$ (therefore required < available)

$\therefore$ will move together.

Ex.16 In above example find maximum F for which two blocks will move together.

Sol. Observing the critical situation where friction becomes limiting.

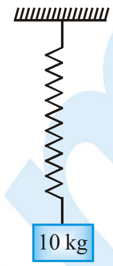


$\therefore$ $F - f_{max} = 10\,a$ .... **(1)**

$f_{max} = 20\,a$ .... **(2)**

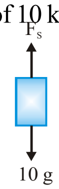
$\therefore$ $F = 75$ N

Ex. 17 Force constant of a spring is 100 N/m. If a 10 kg block attached with the spring is at rest, then find extension in the spring. ($g = 10\ m/s^2$)



Sol : In this solution, spring is in extended state so spring force acts in upward direction. Let x be the extension in the spring.

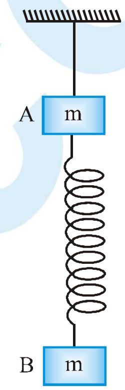
F.B.D. of 10 kg block :



$\Rightarrow$ $F_S = 10\,g \Rightarrow Kx = 100$

$(100)x = (100) \Rightarrow x = 1\ m$

Ex. 18 Two blocks 'A' and 'B' of same mass 'm' attached with a light spring are suspended by a spring as shown in figure. Find the acceleration of block 'A' and 'B' just after the spring is cut.

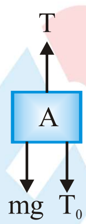


Sol: When block A and B are in equilibrium position

F.B.D of 'B'

$T_0 = mg$ .... **(i)**

F.B.D of 'A'

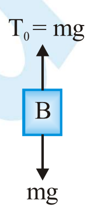


$T = mg + T_0$

$T = 2\,mg$ .... **(ii)**

When string is cut, tension T becomes zero. But spring does not change its shape just after cutting. So spring force acts on mass B, again draw F.B.D. of block A and B as shown in figure.

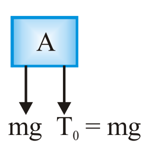
F.B.D. of 'B'



$T_0 - mg = ma_B$

$a_B = 0$

F.B.D. of 'A'

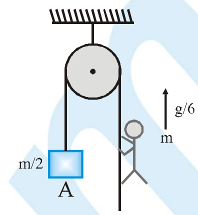


$mg + T_0 = ma_A$

$2mg = ma_A$

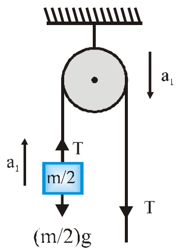
$a_A = 2g$ (downwards)

Ex. 19 Block A of mass m/2 is connected to one end of light rope which passes over a pulley as shown in figure. Man of mass c climbs the other end of rope with a relative acceleration of g/6 with respect to rope. Find acceleration of block A and tension in the rope.

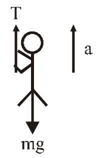


Sol:

FBD of block



FBD of man



a and a_1 are w.r.t ground.

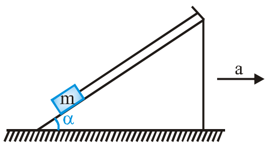
$a + a_1 = g/6$

$$T - \frac{m}{2}g = \frac{m}{2}a_1$$

$T - mg = ma$ on solving above equations we get $T = \frac{13}{18}mg$ and $a_1 = \frac{4}{9}g$

Paragraph for question No. 20 to 22

A body of mass m = 1.8 kg placed on an inclined plane, the angle of inclination is $\alpha = 37^0$, and is attached to the top end of the slope with a thread which is parallel to the slop. Then the slop is moved with a horizontal acceleration of a. Friction is negligible.

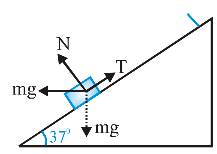


Ex 20 Find the acceleration if the body pushes the slope with a force of $\frac{3}{4}mg$?

Sol. $N = mg\cos37^0 - ma\sin37^0 = \frac{3}{4}mg$

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

FBD of block w.r.t. wedge



Ex 21 Find the tension in thread ?

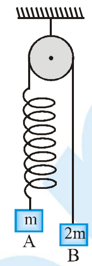
Sol. $T = mg\sin37^0 + ma\cos37^0$ $\Rightarrow$ $T = 12\ N$

Ex 22 At what acceleration with the body lose contact with plane ?

Sol. $N = mg\cos37^0 - ma\sin37^0$ (for lose contact N = 0)

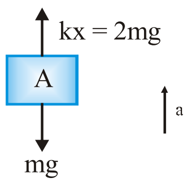
$mg\cos37^0 - ma\sin37^0$ $\Rightarrow$ $a = \frac{40}{3}\ m/s^2$

Ex 23 In the figure 'A' of mass 'm' is attached to one end of a light spring and the other end of the spring is connected to another block 'B' of mass 2m through a light string. 'A' is held and B is at rest in equilibrium. Now A is released. The acceleration of A just after that instant is 'a'. The same thing is repeated for 'B'. In that case the acceleration of 'B' is 'b', then value of a/b is .... ?



Sol. When A is held, B will be at rest in equilibrium, if $kx = T = 2\,mg$

Now, just after A is released

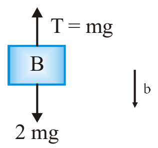


$$a = \frac{2mg - mg}{m} = g$$

When B held and A in equilibrium,

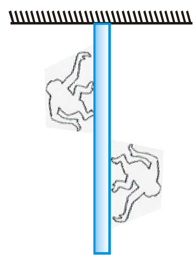
$T = kx = mg$

After B is released,

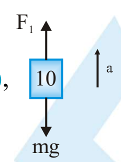


$$b = \frac{2mg - mg}{2m} = g/2 \quad \Rightarrow \quad a/b = 2$$

Ex 24 Two monkey of masses 10 and 8 kg are moving along a vertical rope, the former climbing up with an acceleration of 2m/s. While the latter coming down with a uniform velocity of 2m/s. Find the tension in the rope at the fixed support.



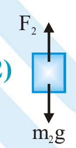
Sol: FBD of monkey **(1)**,



$F_1 - m_1 g = m_1 a$

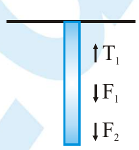
$\Rightarrow \quad F_1 = m_1(g + a) = 10(10 + 2) = 120\,N$

FBD of monkey **(2)**



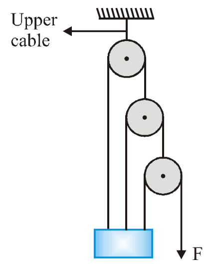
$\Rightarrow \quad F_2 = m_2 g = 10 \times 8 = 80\,N$

FBD of rope



Tension $= F_1 + F_2 = 120 + 80 = 200\,N$

Ex 25 The pull F is just sufficient to keep the 14 N block in equilibrium as shown. Pulleys are ideal. Find the tension (in N) in the upper cable.



Sol: $T_1 = F$

$T_2 = 2T_1 = 2F$

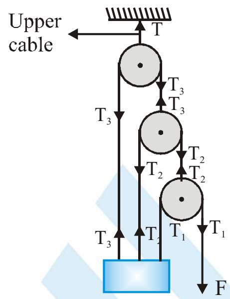
$T_3 = 2T_2 = 4F$

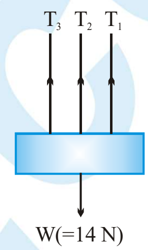
$T = 2T_3 = 8F$

For equilibrium of block $T_1 + T_2 + T_3 = 14$

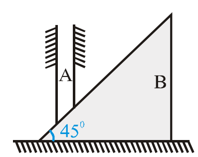
$\Rightarrow \quad 7F = 14 \quad \Rightarrow \quad F = 2\text{ N}$

$\therefore \quad T = 8F = 16\text{ N}$

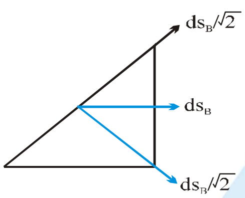


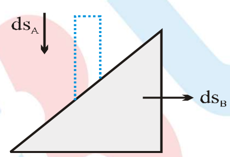


Ex 26 Find the acceleration of rod A and wedge B in the arrangement shown in fig. If the mass of rod equal that of the wedge and the friction between all contact surfaces is negligible. Take angle wedge as 45^0.

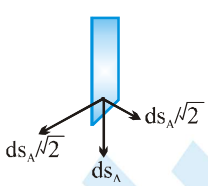


Sol:





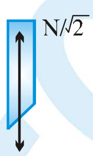
Perpendicular to the plane of contact displacement must be same.



$$\frac{ds_B}{\sqrt{2}} = \frac{ds_A}{\sqrt{2}}$$

$$ds_B = ds_A$$

Differentiating, $a_B = a_A = a$ (Let)



$mg - N/\sqrt{2} = ma$ .... **(i)**

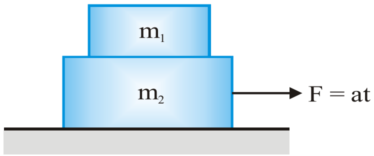
$N/\sqrt{2} = ma$ ....**(ii)**

Equation (i) + (ii)

$\Rightarrow \quad mg = 2ma$

$\Rightarrow \quad a = g/2$

Ex 27 A bar of mass m1 is placed on a plank of mass m_2 which rests on a smooth horizontal plane. The coefficient of friction between the surfaces of the bar and the plank is equal to μ. The plank is subjected to the horizontal force F depending on time t as F = at (a is a constant).

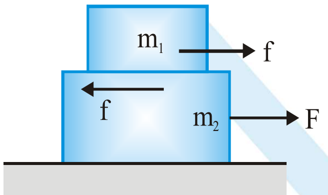


Find **(A)** the moment of time t_0 at which the plank starts sliding from under the bar and

(B) the acceleration of the bar a_1 and that of plank a_2 during motion.

Sol: As the force F grows, so does the static friction force f_s. However, the friction force f has the limiting value $f_{limit} = \mu m_1 g$. Unless this value is reached, both bodies move together with equal accelerations. Bus as soon the force f reaches this limit, mass m_2 starts sliding under mass m_1.

Let us make free-body diagram



Writing Newton's second law for the plank and the bar, having taken the positive direction of the x-axis

$$f = m_1a_1,\ F - f = m_2a_2$$

Acceleration of m_2 must be always greater than or equal to the acceleration of m_1 that is $a_2 \geq a_1$ where the equality corresponds to the moment $t = t_0$. Hence, when $f = \mu m_1 g$, then sliding begins. Putting $f = \mu m_1 g$.

$$t_0 = (m_1 + m_2)\frac{\mu g}{a}$$

When $t \leq t_0$, then $$a_1 = a_2 = \frac{at}{(m_1 + m_2)}$$

and when $t > t_0$ then they separate. Only force acting on m_1 is friction, whose value is constant.

Thus $a_1 = \mu g$ = constant

Now m_2 is experiencing force F and constant friction

thus, $at - \mu m_1 g = m_2 a_2$

Solving we get

$$a_2 = \frac{(at - \mu m_1 g)}{m_2}$$

You may have been tempted to think that when external force F (=at) is equal to $\mu m_1 g$, slipping will being. You can check that at this instant t_2 they are moving with same acceleration.

$$at_2 = \mu m_1 g \quad \Rightarrow \quad t_2 = \frac{\mu m_1 g}{a}$$

Let's find force of friction between the blocks at this instant.

$\mu m_1 g - f = m_2 a \quad \Rightarrow \quad f = m_1 a$

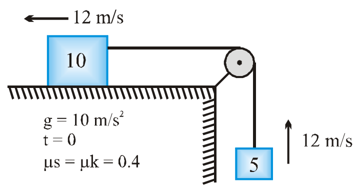
Solving for friction

$$f = \frac{\mu m_1 g}{\left(1 + \frac{m_2}{m_1}\right)}$$

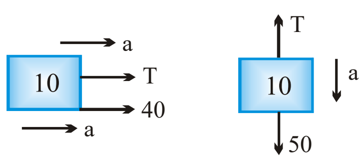
Since friction is less than the limiting value, slipping has not yet begun.

Ex. 28 Blocks are given velocities as shown at t = 0, find velocity and position of 10 kg block.

(A) at t = 1 sec **(B)** at t = 4 sec



Sol. making F.B.D.



(A) $40 + T = 10a$; $50 - T = 5a$; $a = 6\ m/s^2$; $u = 12$; $a = -6$

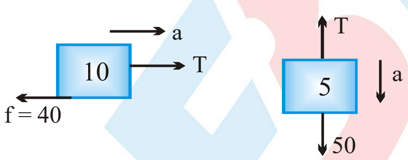
$v = 12 - 6 \times 1 = 6 m/s$ $\quad s = 12 \times 1 - 3 \times 1 = 9\ m$

(B) Let them solve it wrong. Then explain that since velocity has changed the direction during motion friction would also have changed thus direction and acceleration will change.

$u = 12$; $a = -6$ (till velocity becomes zero)

$v = 0$ $\quad v = 2$ sec ; $s = 2 \times 2 - 3 \times 4 = 12\ m$

now FBD



$50 - T = 5a \Rightarrow T - 40 = 10a \Rightarrow a = 2/3\ m/s^2 \Rightarrow u = 0, a = 2/3, t = 2, v = 4/3$

$s = \frac{1}{2} \times \frac{2}{3} \times 4 = \frac{4}{3}$; $\quad$ total displacement $12 - \frac{4}{3} = \frac{32}{3}$ m

Exercise # 1

[Single Correct Choice Type Questions]

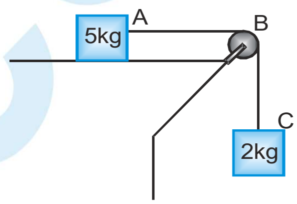
1. A monkey is descending from the branch of a tree with constant acceleration. If the breaking strength of branch is 75% of the weight of the monkey, the minimum acceleration with which the monkey can slide down without breaking the branch is

(A) g **(B)** $\frac{3g}{4}$ **(C)** $\frac{g}{4}$ **(D)** $\frac{g}{2}$

2. A body of mass m_1 exerts a force on another body of mass m_2. If the magnitude of acceleration of m_2 is a_2, then the magnitude of the acceleration of m_1 is (considering only two bodies in space)

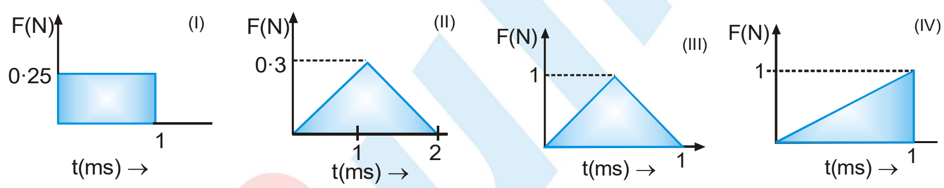
(A) Zero **(B)** $\frac{m_2 a_2}{m_1}$ **(C)** $\frac{m_1 a_2}{m_2}$ **(D)** a_2

3. A trolley of mass 5 kg on a horizontal smooth surface is pulled by a load of mass 2 kg by means of uniform rope ABC of length 2 m and mass 1 kg. As the load falls from BC = 0 to BC = 2m. its acceleration in m/s^2 changes–



(A) $\frac{20}{6}$ to $\frac{20}{5}$ **(B)** $\frac{20}{8}$ to $\frac{30}{8}$ **(C)** $\frac{20}{5}$ to $\frac{30}{6}$ **(D)** None of the above

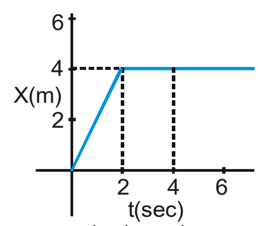
4. Figures I, II, III and IV depicts variation of force with time



In which situation impulse will be maximum

(A) I & II **(B)** III & I **(C)** III & IV **(D)** Only IV

5. In the figure, the position–time graph of a particle of mass 0·1 kg is shown. The impulse at t=2 second is



(A) $0{\cdot}2\ kgms^{-1}$ **(B)** $-0{\cdot}2\ kgms^{-1}$

(C) $0{\cdot}1\ kgms^{-1}$ **(D)** $-0{\cdot}4\ kgms^{-1}$

6. A pulley is attached to the ceiling of a lift moving upwards. Two particles are attached to the two ends of a string passing over the pulley. The masses of the particles are in the ratio 2 : 1. If the acceleration of the particles is g/2, then the acceleration of the lift will be

(A) g **(B)** $\frac{g}{2}$ **(C)** $\frac{g}{3}$ **(D)** $\frac{g}{4}$

7. A monkey is sitting on the pan of a spring balance which is placed on an elevator. The maximum reading of the spring balance will be when :

(A) the elevator is stationary

(B) the string of the elevator breaks and it drops freely towards the earth

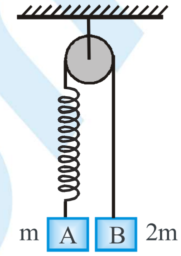
(C) the elevator is accelerated downwards

(D) the elevator is accelerated upwards.

8. A body kept on a smooth inclined plane inclination 1 in x will remain stationary relative to the inclined plane if the plane is given a horizontal acceleration equal to :–

(A) $\sqrt{x^2-1}\,g$ **(B)** $\frac{\sqrt{x^2-1}}{x}g$ **(C)** $\frac{gx}{\sqrt{x^2-1}}$ **(D)** $\frac{g}{\sqrt{x^2-1}}$

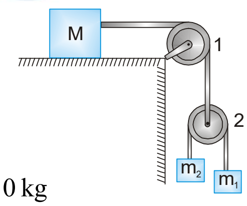
9. Two blocks A and B of masses m & 2m respectively are held at rest such that the spring is in natural length. What is the acceleration of both the blocks just after release ?



(A) $g\downarrow, g\downarrow$ **(B)** $\frac{g}{3}\downarrow, \frac{g}{3}\uparrow$

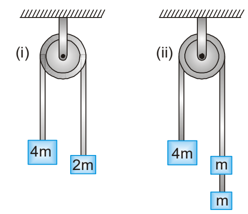
(C) 0, 0 **(D)** $g\downarrow$, 0

10. In the arrangement shown in figure m_1 = 1kg, m_2 = 2kg. Pulleys are massless and strings are light. For what value of M the mass m_1 moves with constant velocity (Neglect friction)



(A) 6 kg **(B)** 4 kg **(C)** 8 kg **(D)** 10 kg

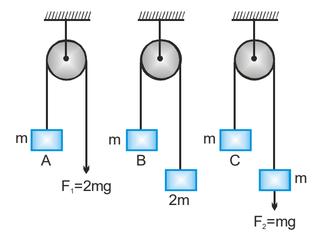
11. In the arrangement shown in figure, pulley is smooth and massless and all the strings are light. Let F_1 be the force exerted on the pulley in case (i) and F_2 the force in case (ii). Then



(A) $F_1 > F_2$ **(B)** $F_1 < F_2$

(C) $F_1 = F_2$ **(D)** $F_1 = 2F_2$

12. In the figure, the blocks A, B and C of mass m, each have accelerations a_1, a_2 and a_3 respectively. F_1 and F_2 are external forces of magnitudes 2mg and mg respectively.



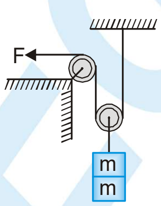
(A) $a_1 = a_2 = a_3$

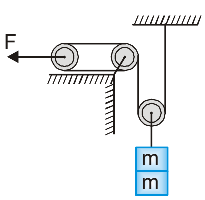
(B) $a_1 > a_3 > a_2$

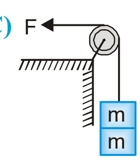
(C) $a_1 = a_2$, $a_2 > a_3$

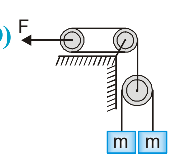
(D) $a_1 > a_2$, $a_2 = a_3$

13. A man thinks about 4 arrangements as shown to raise two small bricks each having mass m. Which of the arrangement would take minimum time?

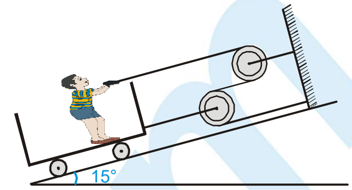
(A) 

(B) 

(C) 

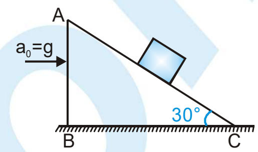
(D) 

14. A trolley is being pulled up an incline plane by a man sitting on it (as shown in figure). He applies a force of 250 N. If the combined mass of the man and trolley is 100 kg, the acceleration of the trolley will be [$\sin 15° = 0.26$]



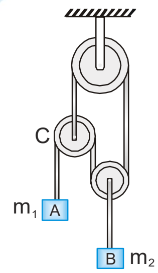
(A) 2.4 m/s^2 **(B)** 9.4 m/s^2
(C) 6.9 m/s^2 **(D)** 4.9 m/s^2

15. A block is placed on an inclined plane moving towards right horizontally with an acceleration $a_0 = g$. The length of the plane AC = 1m. Friction is absent everywhere. The time taken by the block to reach from C to A is
($g = 10\ m/s^2$)



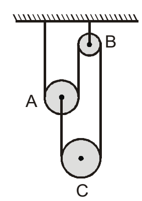
(A) 1.2 s **(B)** 0.74 s **(C)** 2.56 s **(D)** 0.42 s

16. In the arrangement shown in figure neglect the masses of the pulley and string and also friction. The accelerations of blocks A and B are



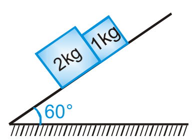
(A) g, g/2
(B) g/2, g
(C) 3g/2, 3g/4
(D) g, g

17. In the arrangement shown in figure pulley A and B are massless and the thread is inextensible. Mass of pulley C is equal to m. If friction in all the pulleys is negligible, then



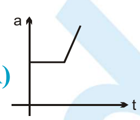
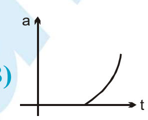
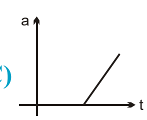
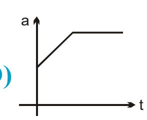
(A) tension in thread is equal to 1/2 mg
(B) acceleration of pulley C is equal to g/2 (downward)
(C) acceleration of pulley A is equal to g/2 (upward)
(D) acceleration of pulley A is equal to 2g (upward)

18. In the figure shown if friction coefficient of block 1kg and 2kg with inclined plane is μ_1=0.5 and μ_2 = 0.4 respectively, then

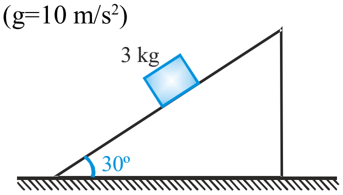


(A) both block will move together
(B) both block will move separately
(C) there is a non zero contact force between two blocks
(D) None of these

19. A block is placed on a rough horizontal plane. A time dependent horizontal force F = kt acts on the block. Here k is a positive constant. Acceleration–time graph of the block is

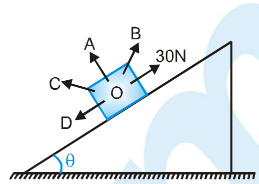
(A) 
(B) 
(C) 
(D) 

20. A block of mass 3 kg is at rest on a rough inclined plane as shown in the figure. The magnitude of net force exerted by the surface on the block will be ($g=10\ m/s^2$)



(A) 26 N **(B)** 19.5 N **(C)** 10 N **(D)** 30 N

21. A block of mass of 10 kg lies on a rough inclined plane of inclination $\theta = \sin^{-1}\left(\frac{3}{5}\right)$ with the horizontal when a force of 30N is applied on the block parallel to and upward the plane, the total force exerted by the plane on the block is nearly along (coefficient of friction is $\mu = \frac{3}{4}$) ($g = 10\ m/s^2$)

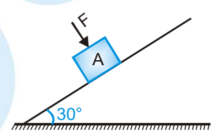


(A) OA **(B)** OB **(C)** OC **(D)** OD

22. A block of mass 0.1 kg is held against a wall applying a horizontal force of 5N on the block. If the coefficient of friction between the block and the wall is 0.5, the magnitude of the frictional force acting on the block is :–

(A) 2.5 N **(B)** 0.98 N **(C)** 4.9 N **(D)** 0.49 N

23. A block of mass m = 2 kg is resting on a rough inclined plane of inclination 30^0 as shown in figure. The coefficient of friction between the block and the plane is $\mu = 0.5$. What minimum force F should be applied perpendicular to the plane on the block, so that block does not slip on the plane ($g=10 m/s^2$)

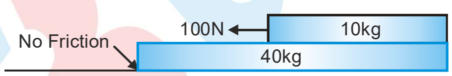


(A) zero **(B)** 6.24 N **(C)** 2.68 N **(D)** 4.34 N

24. The rear side of a truck is open and a box of mass 20 kg is placed on the truck 4m away from the open end, $\mu = 0.15$ and $g=10\ m/sec^2$. The truck starts from rest with an acceleration of $2 m/sec^2$ on a straight road. The distance moved by the truck when box starts fall down.

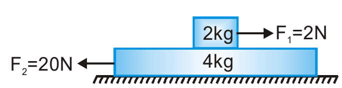
(A) 4 m **(B)** 8 m **(C)** 16 m **(D)** 32 m

25. A 40 kg slab rests on a frictionless floor. A 10 kg block rests on top of the slab. The static coefficient of friction between the block and slab is 0.60 while the kinetic coefficient is 0.40. The 10 kg block is acted upon by a horizontal force of 100N. If $g = 9.8\ m/s^2$, the resulting acceleration of the slab will be :–



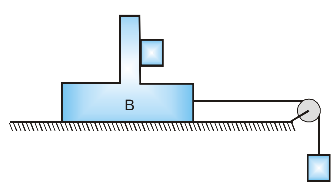
(A) $0.98\ m/s^2$ **(B)** $1.47\ m/s^2$ **(C)** $1.52\ m/s^2$ **(D)** $6.1\ m/s^2$

26. In the arrangement shown in figure, coefficient of friction between the two blocks is $\mu = \frac{1}{2}$. The force of friction acting between the two blocks is



(A) 8 N **(B)** 10 N **(C)** 6 N **(D)** 4 N

27. In the arrangement shown in the figure, mass of the block B and A is 2m and m respectively. Surface between B and floor is smooth. The block B is connected to the block C by means of a string pulley system. If the whole system is released, then find the minimum value of mass of block C so that A remains stationary w.r.t. B. Coefficient of friction between A and B is μ.

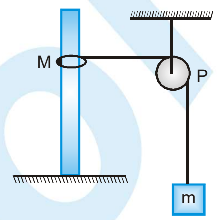


(A) $\frac{m}{\mu}$ **(B)** $\frac{2m+1}{\mu+1}$ **(C)** $\frac{3m}{\mu-1}$ **(D)** $\frac{6m}{\mu+1}$

28. ϕ is the angle of the incline when a block of mass m just starts slipping down. The distance covered by the block if thrown up the incline with an initial speed v_0 is :

(A) $\dfrac{v_0^2}{4g\sin\phi}$ **(B)** $\dfrac{4v_0^2}{g\sin\phi}$ **(C)** $\dfrac{v_0^2\sin\phi}{4g}$ **(D)** $\dfrac{4v_0^2\sin\phi}{g}$

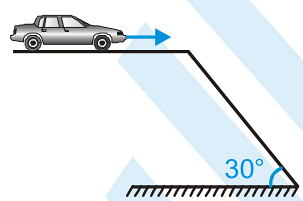
29. In the figure shown a ring of mass M and a block of mass m are in equilibrium. The string is light and pulley P does not offer any friction and coefficient of friction between pole and M is μ. The frictional force offered by the pole on M is



(A) Mg directed up **(B)** μ mg directed up

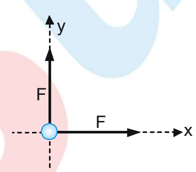
(C) (M – m) g directed down **(D)** μ mg direction down

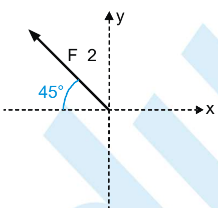
30. A car is going at a speed of 6 m/s when it encounters a 15 m slope of angle 30^0. The friction coefficient between the road and tyre is 0.5. The driver applies the brakes. The minimum speed of car with which it can reach the bottom is (g= $10 m/s^2$)

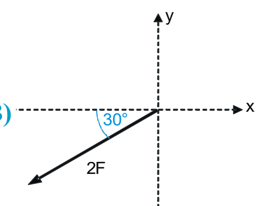


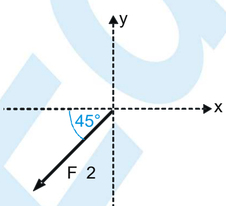
(A) 4 m/s **(B)** 3 m/s **(C)** 7.49 m/s **(D)** 8.45 m/s

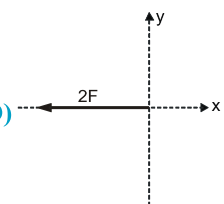
31. Two forces are simultaneously applied on an object. What third force would make the net force to point to the left (–x direction) ?



(A) 

(B) 

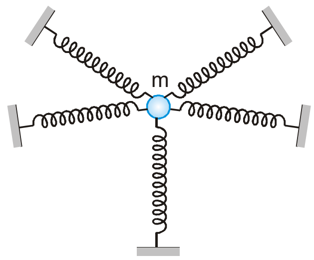
(C) 

(D) 

32. If you want to pile up sand onto a circular area of radius R. The greatest height of the sand pile that can be erected without spilling the sand onto the surrounding area, if μ is the coefficient of friction between sand particle is :-

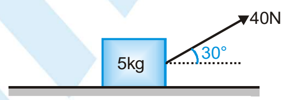
(A) R **(B)** $\mu^2 R$ **(C)** μR **(D)** $\frac{R}{\mu}$

33. A sphere of mass m is kept in equilibrium with the help of several springs as shown in the figure. Measurement shows that one of the springs applies a force $\vec{F}$ on the sphere. With what acceleration the sphere will move immediately after this particular spring is cut?



(A) zero **(B)** $\vec{F}/m$ **(C)** $-\vec{F}/m$ **(D)** insufficient information

34. The adjoining figure shows a force of 40 N pulling a body of mass 5 kg in a direction 30° above the horizontal. The body is in rest on a smooth horizontal surface. Assuming acceleration of free-fall is 10 m/s^2. Which of the following statements I and II is/are correct?

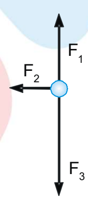


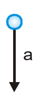
I. The weight of the 5 kg mass acts vertically downwards

II. The net vertical force acting on the body is 30 N.

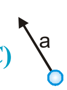
(A) Only I. **(B)** Only II. **(C)** Both I and II. **(D)** None of them

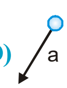
35. Three forces F_1, F_2 and F_3 act on an object simultaneously. These force vectors are shown in the following free-body diagram. In which direction does the object accelerate?



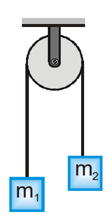
(A) 

(B) 

(C) 

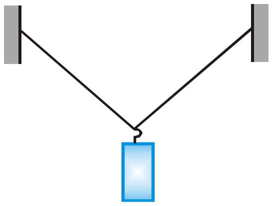
(D) 

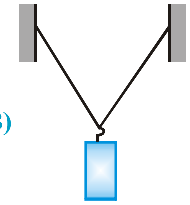
36. An ideal string is passing over a smooth pulley as shown. Two blocks m_1 and m_2 are connected at the ends of the string. If m_1 = 1 kg and tension in the string is 10 N, mass m_2 is equal to (g=10 m/s^2)

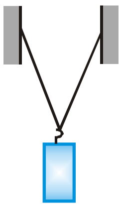


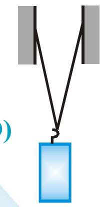
(A) 1 kg **(B)** 1.5 kg **(C)** 2 kg **(D)** 0.5 kg

37. A block of weight W is suspended by a string of fixed length. The ends of the string are held at various positions as shown in the figures below. In which case, if any, is the magnitude of the tension along the string largest?

(A) 

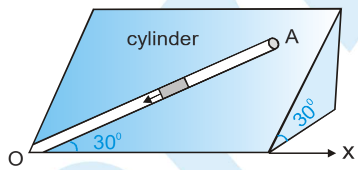
(B) 

(C) 

(D) 

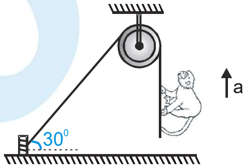
Exercise # 2 Part # I [Multiple Correct Choice Type Questions]

1. An inclined plane makes an angles 30^0 with the horizontal. A groove OA=5m cut in the plane makes an angle 30^0 with OX. A short smooth cylinder is free to slide down the influence of gravity. The time taken by the cylinder to reach from A to O is ($g = 10\ m/s^2$)



(A) 4s **(B)** 2s **(C)** $2\sqrt{2}$ s **(D)** 1s

2. A light string fixed at one end to a clamp on ground passes over a fixed pulley and hangs at the other side. It makes an angle of 30° with the ground. A monkey of mass 5 kg climbs up the rope. The clamp can tolerate a vertical force of 40 N only. The maximum acceleration in upward direction with which the monkey can climb safely is (neglect friction and take $g = 10\ m/s^2$) :

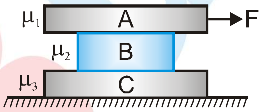


(A) $2\ m/s^2$ **(B)** $4\ m/s^2$ **(C)** $6\ m/s^2$ **(D)** $8\ m/s^2$

3. A block is kept on a smooth inclined plane of angle of inclination 30^0 that moves with a constant acceleration so that the block does not slide relative to the inclined plane. Let F_1 be the contact force between the block and the plane. Now the inclined plane stops and let F_2 be the contact force between the two in this case. Then F_1/F_2 is

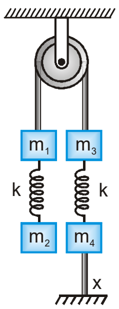
(A) 1 **(B)** $\frac{4}{3}$ **(C)** 2 **(D)** $\frac{3}{2}$

4. Given $m_A = 30$ kg, $m_B = 10$ kg, $m_C = 20$ kg. The coefficient of friction between A and B $\mu_1 = 0.3$, between B and C $\mu_2 = 0.2$ and between C, and ground, $\mu_3 = 0.1$. The least horizontal force F to start motion of any part of the system of three blocks resting upon one another as shown in figure is ($g = 10\ m/s^2$)



(A) 60 N **(B)** 90 N **(C)** 80 N **(D)** 150 N

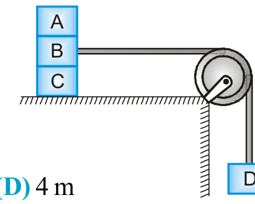
5. For the system shown in the figure, the acceleration of the mass m_4 immediately after the lower thread x is cut will be, (assume that the threads are weightless and inextensible, the spring are weightless, the mass of pulley is negligible and there is no friction)



(A) 0 **(B)** $\left(\frac{m_1 + m_2 - m_3}{m_4}\right)g$

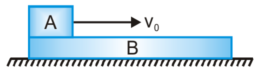
(C) $\left(\frac{m_1 + m_2 - m_3 - m_4}{m_4}\right)g$ **(D)** $\frac{g}{4}$

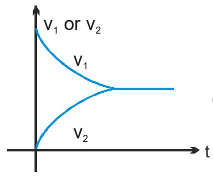
6. Three blocks A , B and C of equal mass m are placed one over the other on a smooth horizontal ground as shown in figure. Coefficient of friction between any two blocks of A,B and C is $\frac{1}{2}$. The maximum value of mass of block D so that the blocks A, B and C move without slipping over each other is

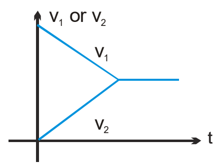


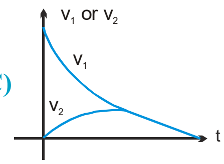
(A) 6 m **(B)** 5 m **(C)** 3 m **(D)** 4 m

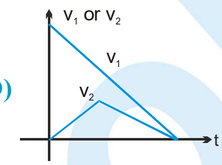
7. A block A is placed over a long rough plank B of same mass as shown in figure. The plank is placed over a smooth horizontal surface. At time t=0, block A is given a velocity v_0 in horizontal direction. Let v_1 and v_2 be the velocities of A and B at time t. Then choose the correct graph between v_1 or v_2 and t.



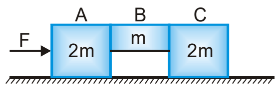
(A) 

(B) 

(C) 

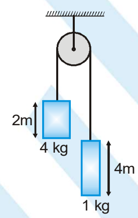
(D) 

8. The system is pushed by a force F as shown in figure. All surfaces are smooth except between B and C. Friction coefficient between B and C is μ. Minimum value of F to prevent block B from downward slipping is



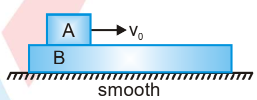
(A) $\left(\frac{3}{2\mu}\right)mg$ **(B)** $\left(\frac{5}{2\mu}\right)mg$ **(C)** $\left(\frac{5}{2}\right)\mu mg$ **(D)** $\left(\frac{3}{2}\right)\mu mg$

9. In figure shown, both blocks are released from rest. The time to cross each other is



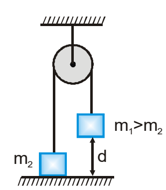
(A) 2 second **(B)** 3 second **(C)** 1 second **(D)** 4 second

10. A block A of mass m is placed over a plank B of mass 2m. Plank B is placed over a smooth horizontal surface. The coefficient of friction between A and B is 0.5. Block A is given a velocity v_0 towards right. Acceleration of B relative to A is



(A) $\frac{g}{2}$ **(B)** g **(C)** $\frac{3g}{4}$ **(D)** zero

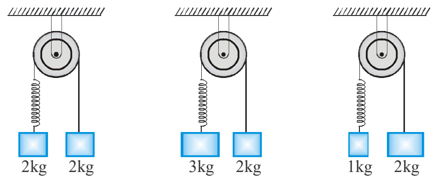
11. If masses are released from the position shown in figure then time elapsed before mass m_1 collides with the floor will be :



(A) $\sqrt{\frac{2m_1gd}{m_1+m_2}}$ **(B)** $\sqrt{\frac{2(m_1+m_2)d}{(m_1-m_2)g}}$

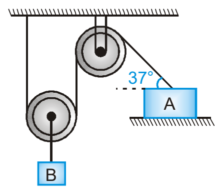
(C) $\sqrt{\frac{2(m_1-m_2)d}{(m_1+m_2)g}}$ **(D)** None of these

12. Same spring is attached with 2kg, 3kg and 1 kg blocks in three different cases as shown in figure. If x_1, x_2 and x_3 be the extensions in the spring in these three cases then



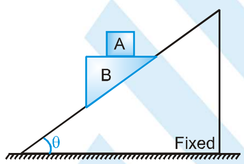
(A) $x_1 = 0, x_3 > x_2$ **(B)** $x_2 > x_1 > x_3$ **(C)** $x_3 > x_1 > x_2$ **(D)** $x_1 > x_2 > x_3$

13. In the figure shown block B moves down with a velocity 10 m/s. The velocity of A in the position shown is



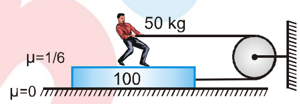
(A) 12.5 m/s **(B)** 25 m/s **(C)** 6.25 m/s **(D)** None of these

14. Block A of mass m is placed over a wedge B of same mass m. Assuming all surfaces to be smooth. The displacement of block A in 1 s if the system is released from rest is



(A) $g\dfrac{(1+\sin^2\theta)}{(1-\sin^2\theta)}$ **(B)** $\dfrac{g\sin\theta}{2}$ **(C)** $g\dfrac{\cos^2\theta}{1+\sin^2\theta}$ **(D)** $g\dfrac{\sin^2\theta}{1+\sin^2\theta}$

15. A man of mass 50 kg is pulling on a plank of mass 100 kg kept on a smooth floor as shown with force of 100 N. If both man & plank move together, find force of friction acting on man.



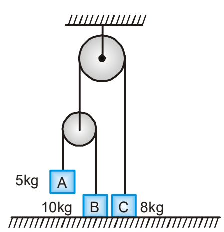
(A) $\dfrac{100}{3}$ N towards left **(B)** $\dfrac{100}{3}$ N towards right

(C) $\dfrac{250}{3}$ N towards left **(D)** $\dfrac{250}{3}$ N towards right

16. A particle is moving along the circle $x^2 + y^2 = a^2$ in anticlockwise direction. The x–y plane is a rough horizontal stationary surface. At the point $(a\cos\theta, a\sin\theta)$, the unit vector in the direction of friction on the particle is

(A) $\cos\theta\,\hat{i} + \sin\theta\hat{j}$ **(B)** $-\left(\cos\theta\hat{i} + \sin\theta\hat{j}\right)$ **(C)** $\sin\theta\hat{i} - \cos\theta\hat{j}$ **(D)** $\cos\theta\hat{i} - \sin\theta\hat{j}$

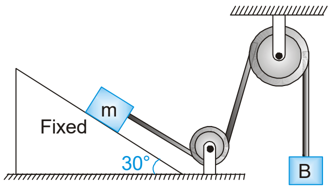
17. In the following arrangement the system is initially at rest. The 5 kg block is now released. Assuming the pulleys and string to be massless and smooth, the acceleration of blocks is



(A) $a_A = \dfrac{g}{7}$ **(B)** $a_B = 0\ m/s^2$

(C) $a_c = \dfrac{5}{7}\ m/s^2$ **(D)** $2a_C = a_A$

18. Two blocks A and B of equal mass m are connected through a massless string and arranged as shown in figure. Friction is absent everywhere. When the system is released from rest.



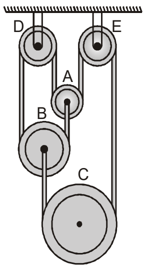
(A) tension in string is $\frac{mg}{2}$ **(B)** tension in string is $\frac{mg}{4}$

(C) acceleration of A is $\frac{g}{2}$ **(D)** acceleration of A is $\frac{3}{4}g$

19. In order to raise a mass of 100 kg a man of mass 60 kg fastens a rope to it and passes the rope over a smooth pulley. He climbs the rope with an acceleration 5g/4 relative to rope. The tension in the rope is ($g = 10 m/s^2$)

(A) 1432 N **(B)** 928 N **(C)** 1218 N **(D)** 642 N

20. In the pulley system shown in figure the movable pulleys A,B and C are of mass 1 kg each. D and E are fixed pulleys. The strings are light and inextensible. Choose the correct alternative(s). All pulleys are frictionless.



(A) tension in the string is 6.5 N

(B) acceleration of pulley A is g/3 downward

(C) acceleration of pulley B is g/6 upward

(D) acceleration of pulley C is g/3 upward

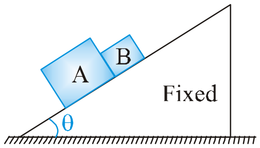
21. In the arrangement shown in figure all surfaces are smooth. Select the correct alternative(s)

(A) for any value of θ acceleration of A and B are equal

(B) contact force between the two blocks is zero if $\frac{m_A}{m_B} = \tan\theta$

(C) contact force between the two is zero for any value of m_A or m_B

(D) normal reactions exerted by the wedge on the blocks are equal



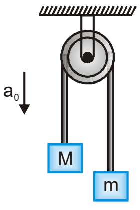
22. If the acceleration of the elevator $a_0 > g$, then

(A) the acceleration of the masses will be a_0

(B) the acceleration of the masses will be $(a_0 - g)$

(C) the tension in the string will be $\frac{mM}{M+m}(g - a_0)$

(D) tension in the string will be zero.

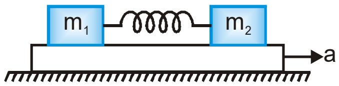


23. A block is placed over a plank. The coefficient of friction between the block and the plank is $\mu = 0.2$. Initially both are at rest, suddenly the plank starts moving with acceleration $a_0 = 4 m/s^2$. The displacement of the block in 1s is ($g = 10 m/s^2$)

(A) 1 m relative to ground **(B)** 1 m relative to plank

(C) zero relative to plank **(D)** 2 m relative to ground

24. Two blocks of masses m_1 and m_2 are connected with a massless spring and placed over a plank moving with an acceleration 'a' as shown in figure. The coefficient of friction between the blocks and platform is μ.



(A) spring will be stretched if $a > \mu g$

(B) spring will be compressed if $a \leq \mu g$

(C) spring will neither be compressed nor be stretched for $a \leq \mu g$

(D) spring will be in its natural length under all conditions

Part # II [Assertion & Reason Type Questions]

These questions contains, Statement 1 (assertion) and Statement 2 (reason).

(A) Statement-I is true, Statement-II is true ; Statement- II is correct explanation for Statement-I.
(B) Statement-I is true, Statement-II is true; Statement-II is NOT a correct explanation for statement-I.
(C) Statement-I is true, Statement-II is false.
(D) Statement-I is false and Statement-II is true.
(E) Statement- I is false, Statement-II is false.

1. **Statement – I** A man who falls from a height on a cement floor receive more injury than when he falls from the same height on a heap of sand.
Statement – II The impulse applied by a cement floor is more than the impulse by sand floor.

2. **Statement – I** A stationary object placed on ground may experience a pseudo force as observed by the reference frame attached to the ground.
Statement – II Earth (a rotating body) is a non–inertial frame.

3. **Statement – I** In Karate a brick is broken with a bare hand.
Statement – II In this process the impulse is sharp.

4. **Statement – I** A larger force is required to start the motion than to maintain it.
Statement – II Kinetic friction coefficient is always less than (or equal to) static friction coefficient.

5. **Statement – I** Aeroplanes always fly at low altitudes.
Statement–II According to Newton's third law of motion, for every action there is an equal and opposite reaction.

6. **Statement – I** A block of mass m is kept at rest on an inclined plane, the net force applied by the surface to the block will be mg.
Statement – II Contact force is the resultant of normal contact force and friction force.

7. **Statement – I** Pulling a lawn roller is easier than pushing it.
Statement – II Pushing increases the apparent weight and hence the force of friction.

8. **Statement – I** When brakes are applied on a wet road , a car is likely to skid.
Statement – II Because brakes prevent rotation of the wheels, and there is not sufficient friction between the road and the wheels.

9. **Statement – I** Two teams having a tug of war always pull equally hard on one another.
Statement – II The team that pushes harder against the ground, in a tug of war, wins.

Exercise # 3

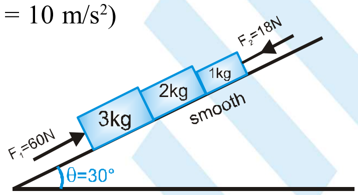
Part # I [Matrix Match Type Questions]

Following question contains statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as p, q, r and s. Any given statement in **Column-I** can have correct matching with **one or more** statement(s) in **Column-II**.

1. Velocity of three particles A, B and C varies with time t as, $\vec{v}_A = (2t\hat{i} + 6\hat{j})$ m/s $\vec{v}_B = (3\hat{i} + 4\hat{j})$ m/s and $\vec{v}_C = (6\hat{i} - 4t\hat{j})$ m/s. Regarding the pseudo force match the following table :–

	Column I		Column II
(A)	On A as observed by B	(p)	Along positive x–direction
(B)	On B as observed by C	(q)	Along negative x–direction
(C)	On A as observed by C	(r)	Along positive y–direction
(D)	On C as observed by A	(s)	Along negative y–direction
		(t)	Zero

2. In the diagram shown in figure (g = 10 m/s²)

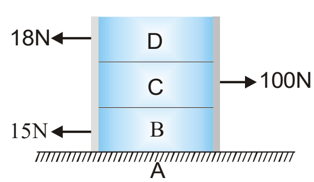


	Column I		Column II
(A)	Acceleration of 2kg block	(p)	8 SI unit
(B)	Net force on 3kg block	(q)	25 SI unit
(C)	Normal reaction between 2kg and 1kg	(r)	2 SI unit
(D)	Normal reaction between 3kg and 2kg	(s)	45 N
		(t)	None

Part # II [Comprehension Type Questions]

Comprehension # 1

Each of the three plates has a mass of 10 kg. If the coefficients of static and kinetic friction at each surface of contact are $\mu_s = 0.3$ and $\mu_k = 0.2$, respectively (g=10 ms^{-2})



1. The acceleration of block B is

(A) zero **(B)** 3.336 m/s^2 **(C)** 4.11 m/s^2 **(D)** 5 m/s^2

2. The acceleration of block C is :

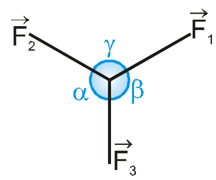
(A) zero **(B)** 3.336 m/s^2 **(C)** 4 m/s^2 **(D)** 5 m/s^2

3. The acceleration of block D is :

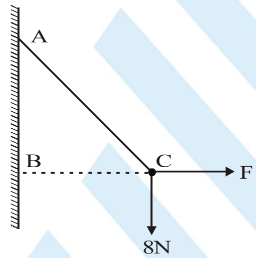
(A) 2 m/s^2 **(B)** 0.2 m/s^2 **(C)** 5 m/s^2 **(D)** 3.36 m/s^2

Comprehension # 2

If three concurrent forces $\vec{F}_1$, $\vec{F}_2$ and $\vec{F}_3$ are in equilibrium then according to Lami's theorem. $\dfrac{F_1}{\sin\alpha} = \dfrac{F_2}{\sin\beta} = \dfrac{F_3}{\sin\gamma}$

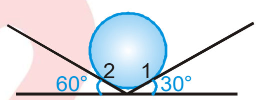


1. One end of a string 0.5 m long is fixed to a point A and other end is fastened to a small object of weight 8N. The object is pulled aside by a horizontal force F, until it is 0.3 m from the vertical through A. The magnitude of the tension T in the string and the force F will be



(A) 6N, 10N **(B)** 10N, 6N **(C)** 8N, 10N **(D)** 3N, 4N

2. A solid sphere of mass 10 kg is placed over two smooth inclined planes as shown in figure. Normal reaction at 1 and 2 will be : (g = 10 m/s^2)



(A) $50\sqrt{3}N, 50N$ **(B)** 50N, 50N **(C)** $50N, 50\sqrt{3}N$ **(D)** 60N, 40N

Comprehension # 3

Experiment 1 : The student pushes horizontally (rightward) on the crate and gradually increases the strength of this push force. The crate does not begin to move until the push force reaches 400 N.

Experiment 2 : The student applies a constant horizontal (rightward) push force for 1.0 s and measures how far the crate moves during that time interval. In each trial the crate starts at rest, and the student stops pushing after the 1.0 s interval. The following table summarizes the results.

Trial	Push force (N)	Distance (m)
1	500	1.5
2	600	2
3	700	2.5

1. The coefficient of static friction between the crate and floor is approximately :

(A) 0.25 (B) 0.40 (C) 2.5 (D) 4.0

2. In experiment 1, when the rightward push force was 50N the crate didn't move. Why didn't it move ?

(A) The push force was weaker than the frictional force on the crate

(B) The push force had the same strength as the gravitational force on the crate

(C) The push force was stronger than the frictional force on the crate

(D) The push force had the same strength as the frictional force on the crate

3. The coefficient of kinetic friction between the crate and the floor is approximately :

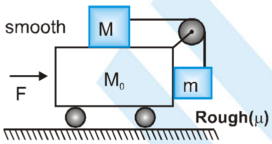
(A) 0.20 (B) 2.0 (C) 3.0 (D) 5.0

4. In trial 3, what is the crate's speed at the moment the student stops pushing it ?

(A) 1.0 m/s (B) 2.0 m/s (C) 3.0 m/s (D) 5.0 m/s

Comprehension # 4

Imagine a situation in which the horizontal surface of block M_0 is smooth and its vertical surface is rough with a coefficient of friction μ .



1. Identify the correct statement(s)

(A) If F = 0, the blocks cannot remain stationary

(B) for one unique value of F, the blocks M and m remain stationary with respect to M_0

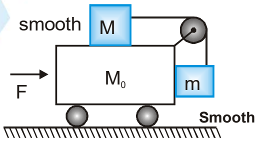
(C) the limiting friction between m and M_0 is independent of F

(D) there exist a value of F at which friction force is equal to zero

2. In above problem, choose the correct value(s) of F which the blocks M and m remain stationary with respect to M_0

(A) $(M_0 + M + m)\dfrac{g}{\mu}$ (B) $\dfrac{m(M_0 + M + m)g}{M - \mu m}$ (C) $(M_0 + M + m)\dfrac{mg}{M}$ (D) None of these

3. Consider a special situation in which both the faces of the block M_0 are smooth, as shown in adjoining figure. Mark out the correct statement(s)



(A) If F = 0, the blocks cannot remain stationary

(B) for one unique value of F, the blocks M and m remains stationary with respect to block M_0

(C) there exist as a range of F for which blocks M and m remain stationary with respect to block M_0

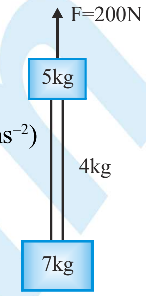
(D) since there is no friction, therefore, blocks M and m cannot be in equilibrium with respect to M_0

4. In above problem, the value(s) of F for which M and m are stationary with respect to M_0

(A) $(M_0 + M + m)g$ (B) $(M_0 + M + m)\dfrac{mg}{M}$ (C) $(M_0 + M + m)\dfrac{Mg}{m}$ (D) None of these

Comprehension # 5

If a string is attached with a block, then it can only pull the block, it can't push the block.



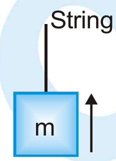
1. Two blocks shown in figure are connected by a heavy rope of mass 4kg. An upward force of 200 N is applied as shown. The tension at the mid-point of the rope is (g = 10 ms^{-2})

(A) 225N

(B) 112.5 N

(C) 90N

(D) None of these



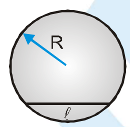
2. A block of mass m is attached with a massless instretchable string. Breaking strength of string is 4 mg. Block is moving up. The maximum acceleration and maximum retardation of the block can be.

(A) 4g, 3g **(B)** 4g, g

(C) 3g, g **(D)** 3g, 4g

Comprehension # 6

A rod of length ●(< 2R) is kept inside a smooth spherical shell as shown in figure. Mass of the rod is m.



1. Keeping mass to be constant if length of the rod is increased (but always < 2R) the normal reactions at two ends of the rod.

(A) Will remain constant **(B)** Will increase **(C)** Will decrease **(D)** May increase or decrease

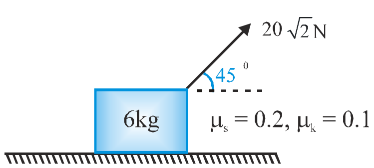
2. The normal reaction when ● = R is :–

(A) $\frac{mg}{2}$ **(B)** $\frac{mg}{4}$ **(C)** $\frac{mg}{2\sqrt{3}}$ **(D)** $\frac{mg}{\sqrt{3}}$

Comprehension # 7

Contact force $\left(\vec{F}_c\right)$ between two bodies is the resultant of force of friction and normal reaction.

1. Contact force for shown position is (g = 10 ms^{-2})



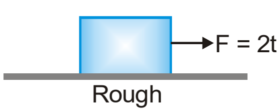
(A) 40N

(B) $\sqrt{1616}$ N

(C) 4N

(D) None of these

2. A time varying force is applied on a block placed over a rough surface as shown in figure. Let θ be the angle between contact force on the block and the normal reaction, then with time, θ will :



(A) Remain constant

(B) First increase to a maximum value (say θ_{max}) and then becomes constant in a value less then θ_{max}

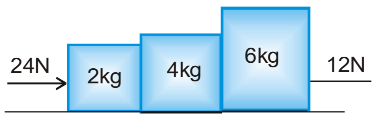
(C) First decrease to a minimum value (say θ_{min}) and then becomes constant in a value more than θ_{min}

(D) None of the above

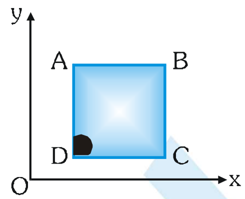
Exercise # 4

[Subjective Type Questions]

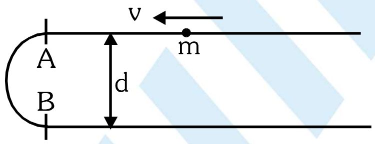
1. If contact force between 2kg and 4kg is f_1 and between 4kg and 6 kg is f_2. Find out f_1 and f_2.



2. A solid sphere of mass 2 kg is resting inside a cube as shown in figure. The cube is moving with a velocity $\vec{v} = (5t\hat{i} + 2t\hat{j})$ m/sec. Here t is the time in second. All surface are smooth. The sphere is at rest with respect to the cube. What is the total force exerted by the sphere on the cube ? (Take g = 10 ms^{-2})



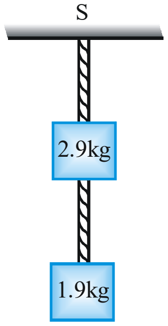
3. Fig. shows a bead of mass m moving with uniform speed v through a U–shaped smooth wire the wire has a semicircular bending between A and B. Calculate The average force exerted by the bead on the part AB of the wire.



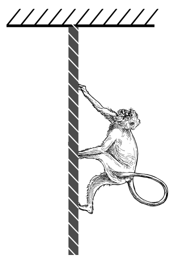
4. Two blocks of mass 2.9 kg and 1.9 kg are suspended from a rigid support S by two inextensible wires each of length 1m (see figure). The upper wire has negligible mass and the lower wire has a uniform mass of 0.2 kg/m. The whole system of blocks, wires and support have an upward acceleration of 0.2 m/s^2. The acceleration due to gravity is 9.8 m/s^2.

(i) Find the tension at the midpoint of the lower wire.

(ii) Find the tension at the midpoint of the upper wire.



5. A monkey of mass 40 kg climbs on a rope which can stand a maximum tension of 600 N. Calculate tension in rope in following cases. In which case will the rope break :

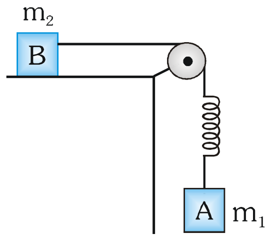


(i) The monkey climbs up with an acceleration of 6 m s^{-2}.

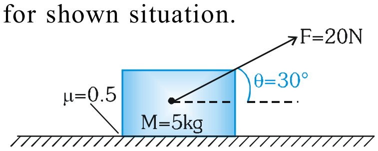
(ii) The monkey climbs down with an acceleration of 4 m s^{-2}.

(iii) The monkey climbs up with a uniform speed of 5 m s^{-1}. Neglect the mass of string.

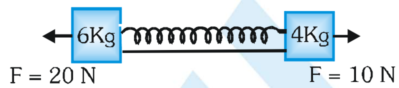
6. If the two blocks moves with a constant uniform speed then find coefficient of friction between the surface of the block B and the table. The spring is massless and the pulley is frictionless.



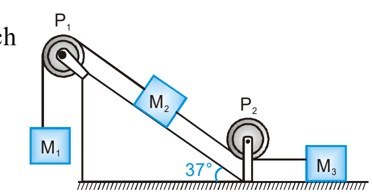
7. Calculate the force of friction for shown situation.



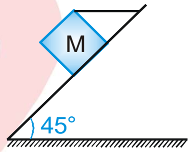
8. A dynamometer is attached to two blocks of masses 6 kg and 4 kg. Forces of 20 N and 10 N are applied on the blocks as shown in figure. Find the dynamometer reading.



9. Masses M_1, M_2 and M_3 are connected by strings of negligible mass which pass over massless and frictionless pulleys P_1 and P_2 as shown in fig. The masses move such that the portion of the string between P_1 and P_2 is parallel to the inclined plane and the portion of the string between P_2 and M_3 is horizontal. The masses M_2 and M_3 are 4.0 kg each and the coefficient of kinetic friction between the masses and the surfaces is 0.25. The inclined plane makes an angle of 37° with the horizontal. If the mass M_1 moves downwards with a uniform velocity, find the mass of M_1.

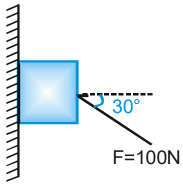


10. A block of mass 15kg is resting on a rough inclined plane as shown in figure. The block is tied up by a horizontal string which has a tension of 50N. Calculate the coefficient of friction between the block and inclined plane.

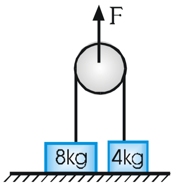


11. A block of mass m rests on a horizontal floor with which it has a coefficient of static friction μ. It is desired to make the body move by applying the minimum possible force F. Find the magnitude of F and the direction in which it has to be applied.

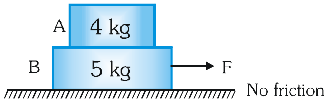
12. A force of 100N is applied on a block of mass 3 kg as shown in figure. The coefficient of friction between the wall and the surface of the block is $\frac{1}{4}$. Calculate frictional force acting on the block.



13. Two block of mass 8 kg and 4kg are connected by a string as shown. Calculate their acceleration if they are initially at rest on the floor, when a force of 100N is applied on the pulley in upward direction ($g = 10ms^{-2}$)

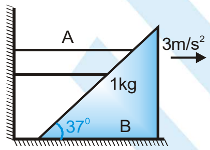


14. 12 N of force required to be applied on A to slip on B. Find the maximum horizontal force F to be applied on B so that A and B moves together.

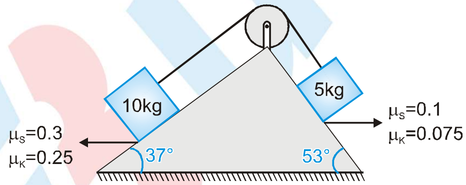


15. A thin rod of length 1 m is fixed in a vertical position inside a train, which is moving horizontally with constant acceleration 4 m/s^2. A bead can slide on the rod, and friction coefficient between them is 1/2. If the bead is released from rest at the top of the rod, find the time when it will reach at the bottom. ($g=10m/s^2$)

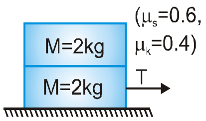
16. Find force in newton which mass A exerts on mass B if B is moving towards right with 3 ms^{-2}. All surfaces are smooth and $g=10m/s^2$.



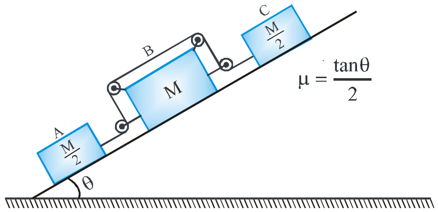
17. A system of two blocks and a light string are kept on two inclined faces (rough) as shown in the figure below. All the required data are mentioned in the diagram. Pulley is light and frictionless. (Take $g = 10$ m/s^2, sin 37° = 3/5) If the system is released from rest then what is the range of the tension in the string?



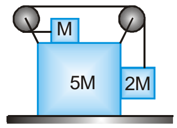
18. The coefficient of static and kinetic friction between the two blocks and also between the lower block and the ground are $\mu_s = 0.6$ and $\mu_k = 0.4$ Find the value of tension T applied on the lower block at which the upper block begins to slip relative to lower block.



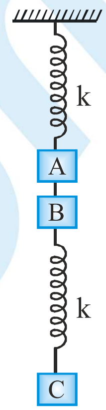
19. As shown in the figure blocks of masses $\frac{M}{2}$, M and $\frac{M}{2}$ are connected through a light string as shown, pulleys are light and smooth. Friction is only between block C and floor. System is released from rest. Find the acceleration of blocks A, B and C and tension in the string.



20. In the system shown. Find the initial acceleration of the wedge of mass 5M. The pulleys are ideal and the chords are inextensible. (There is no friction anywhere)



21. The system shown is in equilibrium. Find the acceleration of the blocks A, B & C all of equal masses m at the instant when (Assume springs to be ideal)



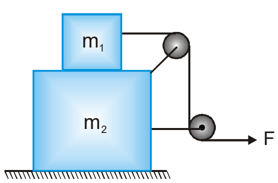
(i) the spring between ceiling & A is cut.

(ii) The string (inextensible) between A & B is cut.

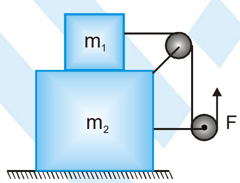
(iii) The spring between B & C is cut.

Also find the tension in the string when the system is at rest and in the above 3 cases.

22. $m_1 = 20$ kg, $m_2 = 30$ kg. m_2 is on smooth surface. Surface between m_1 and m_2 has $\mu_s = 0.5$ and $\mu_k = 0.3$ Find the acceleration of m_1 and m_2 for the following figures **(A)** and **(B)**. When



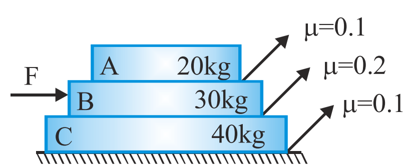
F = 160 N, F = 175 N



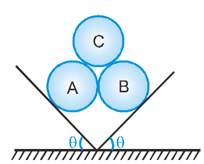
F = 160 N

23. A system of masses is shown in the figure with masses & coefficients of friction indicated. Calculate :

(i) the maximum value of F for which there is no slipping anywhere
(ii) the minimum value of F for which B slides on C
(iii) the minimum value of F for which A slips on B.

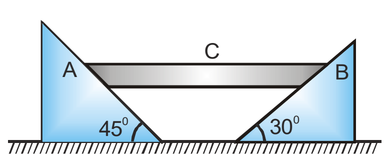


24. Three identical rigid cylinders A,B and C are arranged on smooth inclined surfaces as shown in figure. Find the least value of θ that prevent the arrangement from collapse.

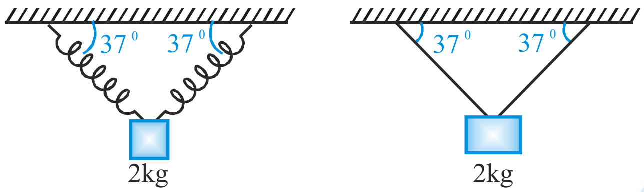


25. A car begins to move at time t = 0 and then accelerates along a straight track with a speed given by $V(t) = 2t^2\ ms^{-1}$ for $0 \le t \le 2$. After the end of acceleration, the car continues to move at a constant speed. A small block initially at rest on the floor of the car begins to slip at t = 1 sec. and stops slipping at t = 3 sec. Find the coefficient of static and kinetic friction between the block and the floor. ($g = 10 m/s^2$)

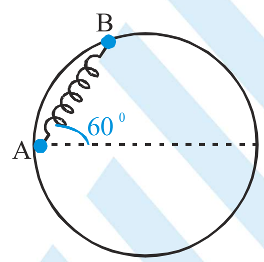
26. Block C descends vertically at 1 m/s. Find the velocity of A relative to B.



27. The blocks are of mass 2 kg shown is in equilibrium. At t=0 right spring in figure(i) and right string in figure (ii) breaks. Find the ratio of instantaneous acceleration of blocks ?



28. A bead of mass m is attached to one end of a spring of natural length $\sqrt{3}$ R and spring constant $k = \frac{(\sqrt{3}+1)mg}{R}$. The other end of the spring is fixed at point A on a smooth fixed vertical ring of radius R as shown in the figure. What is the normal reaction at B just after the bead is released ?

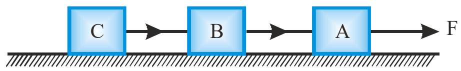


Exercise # 5 Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

1. 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- **[AIEEE - 2002]**

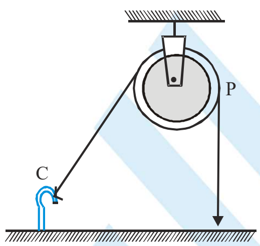
(1) F_1/m **(2)** F_2F_3/mF_1 **(3)** $(F_2 - F_3)/m$ **(4)** F_2/m

2. Three identical blocks of masses m = 2 kg are drawn by a force F 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 **[AIEEE - 2002]**



(1) 9.2 **(2)** 1.2 **(3)** 4 **(4)** 9.8

3. One end of 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 840 N. With what value of maximum safe acceleration (in ms^{-2}) can a man of 60 kg climb on the rope ? **[AIEEE - 2002]**



(1) 16 **(2)** 6 **(3)** 4 **(4)** 8

4. 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- **[AIEEE - 2003]**

(1) both the scales read M kg each
(2) the scale of the lower one reads M kg and of the upper one zero
(3) The reading of the two scales can be anything but the sum of the readings will be M kg
(4) both the scales read M/2 kg

5. 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- **[AIEEE - 2003]**

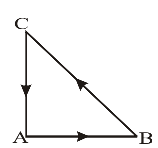
(1) 24 N **(2)** 74 N **(3)** 15 N **(4)** 49 N

6. A rocket which has a mass of 3.5×10^4 kg is blasted upwards with an initial acceleration of 10 m/s^2. Then the initial thrust of the blast is- **[AIEEE - 2003]**

(1) 3.5×10^5 N **(2)** 7.0×10^5 N **(3)** 14.0×10^5 N **(4)** 1.75×10^5 N

7. Three forces start acting simultaneously on a particle moving with velocity $\vec{v}$. These forces are represented in magnitude and direction by the three sides of a triangle ABC (as shown). The particle will now move with velocity- **[AIEEE - 2003]**

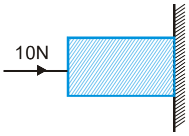
(1) Less than $\vec{v}$
(2) greater than $\vec{v}$
(3) |v| in the direction of largest force BC
(4) $\vec{v}$, remaining unchanged



8. 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- **[AIEEE - 2003]**

(1) $\frac{Pm}{M+m}$ (2) $\frac{Pm}{M-m}$ (3) P (4) $\frac{PM}{M+m}$

9. 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- **[AIEEE - 2003]**



(1) 20 N (2) 50 N (3) 100 N (4) 2 N

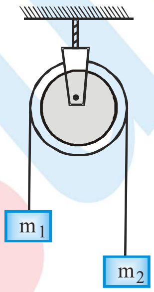
10. A marble block of mass 2 kg lying on ice when given a velocity of 6 m/s is stopped by friction in 10 s. Then the coefficient of friction is- **[AIEEE - 2003]**

(1) 0.02 (2) 0.03 (3) 0.06 (4) 0.01

11. A machine gun fires a bullet of mass 40 g with a velocity 1200 ms^{-1}. The man holding it, can exert maximum force of 144 N on the gun. How many bullets can he fire per second at the most? **[AIEEE - 2004]**

(1) One (2) Four (3) Two (4) Three

12. Two masses m_1 = 5 kg and m_2 = 4.8 kg tied to a string are hanging over a light frictionless pulley. What is the acceleration of the masses when they are free to move ? (g = 9.8 m/s^2) **[AIEEE - 2004]**

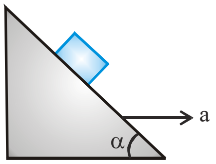


(1) 0.2 m/s^2 (2) 9.8 m/s^2 (3) 5 m/s^2 (4) 4.8 m/s^2

13. 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 : (taken g = 10 m/s^2) **[AIEEE - 2004]**

(1) 2.0 (2) 4.0 (3) 1.6 (4) 2.5

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



(1) g/tan α (2) g cosec α (3) g (4) g tan α

15. 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- **[AIEEE - 2005]**

(1) $\mu_k = 1 - \frac{1}{n^2}$ (2) $\mu_k = \sqrt{1 - \frac{1}{n^2}}$ (3) $\mu_s = 1 - \frac{1}{n^2}$ (4) $\mu_s = \sqrt{1 - \frac{1}{n^2}}$

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

(1) $2 \sin \phi$ (2) $2 \cos \phi$ (3) $2 \tan \phi$ (4) $\tan \phi$

17. Consider a car moving on a straight road with a speed of 100 m/s. The distance at which car can be stopped, is : [$\mu_k = 0.5$] **[AIEEE - 2005]**

(1) 800 m (2) 1000 m (3) 100 m (4) 400 m

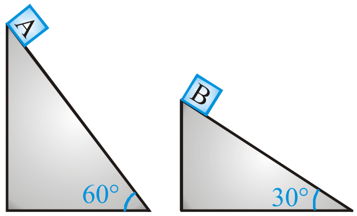
18. A player caught a cricket ball of mass 150 g moving at a rate of 20 m/s. If the catching process is completed in 0.1 s., the force of the blow exerted by the ball on the hand of the player is equal to- **[AIEEE - 2006]**

(1) 150 N (2) 3 N (3) 30 N (4) 300 N

19. A block of mass m is connected to another block of mass M by a spring (massless) of spring constant k. The blocks 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 on the block of mass m :- **[AIEEE - 2007]**

(1) $\frac{mF}{M}$ (2) $\frac{(M+m)F}{m}$ (3) $\frac{mF}{(m+M)}$ (4) $\frac{MF}{(m+M)}$

20. 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 ? **[AIEEE - 2010]**

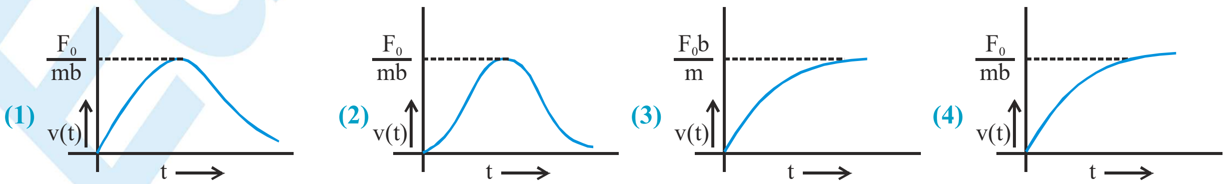


(1) 4.9 ms^{-2} in vertical direction.
(2) 4.9 ms^{-2} in horizontal direction
(3) 9.8 ms^{-2} in vertical direction
(4) Zero

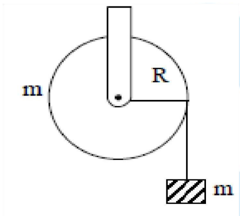
21. The minimum force required to start pushing a body up a rough (frictional coefficient μ) inclined plane is F_1 while the minimum force needed to prevent it from sliding down is F_2. If the inclined plane makes an angle θ from the horizontal such that $\tan\theta = 2\mu$ then the ratio $\frac{F_1}{F_2}$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

(1) 4 (2) 1 (3) 2 (4) 3

22. A particle of mass m is at rest at the origin at time t = 0. It is subjected to a force $F(t) = F_0e^{-bt}$ in the x-direction. Its speed v(t) is depicted by which of the following curves ? **[AIEEE - 2012]**



23. 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 on release ? **[JEE (Main) -2014]**

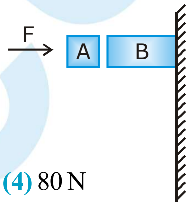


(1) $\frac{5g}{6}$ **(2)** g **(3)** $\frac{2g}{3}$ **(4)** $\frac{g}{2}$

24. 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 :

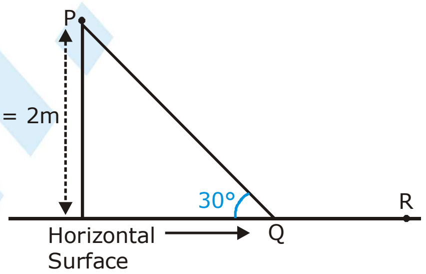
(1) $\frac{1}{3}m$ **(2)** $\frac{1}{2}m$ **(3)** $\frac{1}{6}m$ **(4)** $\frac{2}{3}m$ **[JEE (Main) -2014]**

25. Given 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 : **[JEE (Main) -2015]**



(1) 120 N **(2)** 150 N **(3)** 100 N **(4)** 80 N

26. A point particle of mass m, moves along the uniformly rough track PQR as shown in the figure. The coefficient of friction, between the particle and the rough track equals μ The particle is released, from rest, from the point P and it comes to rest at a point R. The energies, lost by the ball, over the parts, PQ and QR, of the track, are equal to each other, and no energy is lost when particle changes direction from PQ to QR.



The values of the coefficient of friction μ and the distance x(=QR), are, respectively close to: **[JEE (Main) -2016]**

(1) 0.2 and 3.5 m **(2)** 0.29 and 3.5 m **(3)** 0.29 and 6.5 m **(4)** 0.2 and 6.5 m

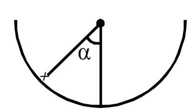
Part # II [Previous Year Questions][IIT-JEE ADVANCED]

1. A long horizontal rod has a bead which can slide along its length and is initially placed at a distance L from one end A of the rod. The rod is set in angular motion about A with a constant angular acceleration, α. If the coefficient of friction between the rod and bead is μ, and gravity is neglected, then the time after which the bead starts slipping is :– **[IIT-JEE 2000]**

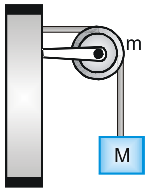
(A) $\sqrt{\frac{\mu}{\alpha}}$ **(B)** $\frac{\mu}{\sqrt{\alpha}}$ **(C)** $\frac{1}{\sqrt{\mu\alpha}}$ **(D)** infinitesimal

2. A insect crawls up a hemispherical surface very slowly (see the figure). The coefficient of friction between the surface and the insect is $\frac{1}{3}$. 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 is given :– **[IIT-JEE 2001]**

(A) cot α = 3
(B) tan α = 3
(C) sec α = 3
(D) cosec α = 3

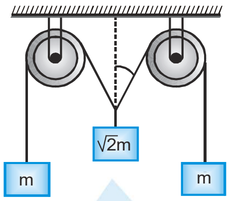


3. A string of negligible mass going over a clamped pulley of mass m supports a block of mass M as shown in the figure. The force on the pulley by the clamp is given by :– **[IIT-JEE 2001]**



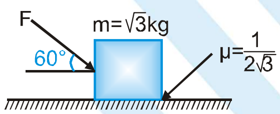
(A) $\sqrt{2}$ Mg **(B)** $\sqrt{2}$ mg **(C)** $\sqrt{(M+m)^2+m^2g}$ **(D)** $\left(\sqrt{(M+m)^2+M^2}\right)g$

4. The pulleys and strings shown in the figure are smooth and of negligible mass. For the system to remain in equilibrium, the angle θ should be :– **[IIT-JEE 2001]**



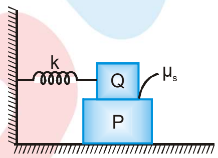
(A) 0° **(B)** 30° **(C)** 45° **(D)** 60°

5. What is the maximum value of the force F such that the block shown in the arrangement, does not move : **[IIT-JEE 2003]**



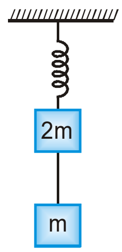
(A) 20 N **(B)** 10 N **(C)** 12 N **(D)** 15 N

6. A block P of mass m is placed on a horizontal frictionless plane. A second block of same mass m is placed on it and is connected to a spring of spring constant k, the two blocks are pulled by distance A. Block Q oscillates without slipping. What is the maximum value of frictional force between the two blocks:–



(A) $\frac{kA}{2}$ **(B)** kA **(C)** $\mu_S mg$ **(D)** zero **[IIT-JEE 2004]**

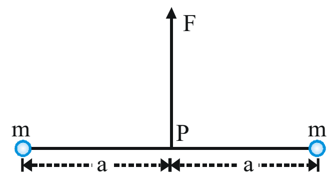
7. System shown in figure is in equilibrium and at rest. The spring and string are massless, now the string is cut. The acceleration of mass 2m and m just after the string is cut will be :– **[IIT-JEE 2006]**



(A) $\frac{g}{2}$ upwards, g downwards **(B)** g upwards, $\frac{g}{2}$ downwards

(C) g upwards, 2g downwards **(D)** 2g upwards, g downwards

8. Two particles of mass m each are tied at the ends of a light string of length 2a. The whole system is kept on a frictionless horizontal surface with the string held tight so that each mass is at the distance a from the centre P (as shown in the figure). Now, the mid–point of the string is pulled vertically upwards with a small but constant force F. As a result, the particles move towards each other on the surface. The magnitude of acceleration, when the separation between them become 2x, is :– **[IIT-JEE 2007]**

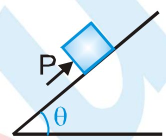


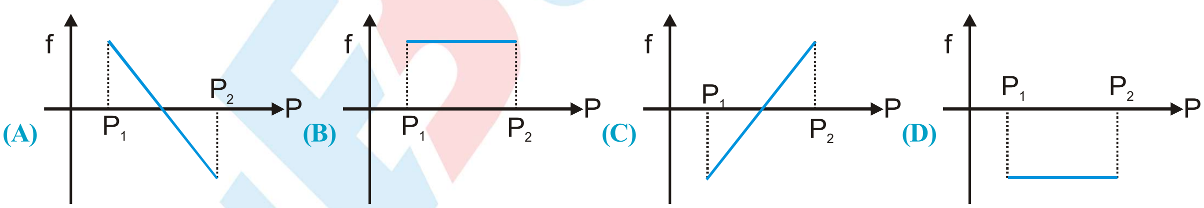
(A) $\frac{F}{2m}\frac{a}{\sqrt{a^2-x^2}}$ **(B)** $\frac{F}{2m}\frac{x}{\sqrt{a^2-x^2}}$ **(C)** $\frac{F}{2m}\frac{x}{a}$ **(D)** $\frac{F}{2m}\frac{\sqrt{a^2-x^2}}{x}$

9. A piece of wire is bent in the shape of a parabola $y = kx^2$ (y-axis vertical) with a bead of mass m on it. The bead can slide on the wire without friction. It stays at the lowest point of the parabola when the wire is at rest. The wire is now accelerated parallel to the x-axis with a constant acceleration a. The distance of the new equilibrium position of the bead, where the bead can stay at rest with respect to the wire, from the y-axis is :- **[IIT-JEE 2009]**

(A) $\frac{a}{gk}$ **(B)** $\frac{a}{2gk}$ **(C)** $\frac{2a}{gk}$ **(D)** $\frac{a}{4gk}$

10. A block of mass m is on an inclined plane of angle θ. The coefficient of friction between the block and the plane is μ and tanθ > μ. The block is held stationary by applying a force P parallel to the plane. The direction of force pointing up the plane is taken to be positive. As P is varied from $P_1 = mg(\sin\theta - \mu\cos\theta)$ to $P_2 = mg(\sin\theta + \mu\cos\theta)$, the frictional force f versus P graph will look like **[IIT-JEE-2010]**





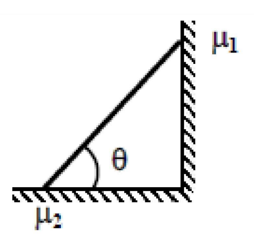
11. In the figure, a ladder of mass m is shown leaning against a wall. It is in static equilibrium making an angle θ with the horizontal floor. The coefficient of friction between the wall and the ladder is μ_1 and that between the floor and the ladder is μ_2. The normal reaction of the wall on the ladder is N_1 and that of the floor is N_2. If the ladder is about to slip, then **[IIT-JEE-2014]**

(A) $\mu_1 = 0$ $\mu_2 \neq 0$ and $N_2 \tan\theta = \frac{mg}{2}$

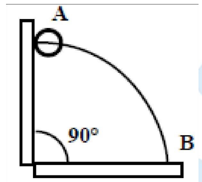
(B) $\mu_1 \neq 0$ $\mu_2 = 0$ and $N_1 \tan\theta = \frac{mg}{2}$

(C) $\mu_1 \neq 0$ $\mu_2 \neq 0$ and $N_2 = \frac{mg}{1+\mu_1\mu_2}$

(D) $\mu_1 = 0$ $\mu_2 \neq 0$ and $N_1 \tan\theta = \frac{mg}{2}$

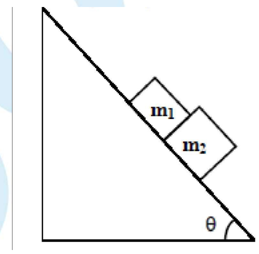


12. A wire, which passes through the hole in a small bead, is bent in the form of quarter of a circle. The wire is fixed vertically on ground as shown in the figure. The bead is released from near the top of the wire and it slides along the wire without friction. As the bead moves from A to B, the force it applies on the wire is **[IIT-JEE-2014]**



(A) always radially outwards.
(B) always radially inwards.
(C) radially outwards initially and radially inwards later.
(D) radially inwards initially and radially outwards later.

13. A block of mass $m_1 = 1$ kg another mass $m_2 = 2$kg, are placed together (see figure) on an inclined plane with angle of inclination θ. Various values of θ are given in List I. The coefficient of friction between the block m_1 and the plane is always zero. The coefficient of static and dynamic friction between the block m_2 and the plane are equal to $\mu = 0.3$. In List II expressions for the friction on the block m_2 are given. Match the correct expression of the friction in List II with the angles given in List I, and choose the correct option. The acceleration due to gravity is denoted by g.
[**Useful information:** tan (5.5°) ≈10.1; tan (11.5°) ≈ 0.2; tan (16.5°) ≈ 0.3]
[IIT-JEE-2014]



List I	List II
P. $\theta = 5°$	**1.** $m_2 g \sin\theta$
Q. $\theta = 10°$	**2.** $(m_1+m_2)\, g \sin\theta$
R. $\theta = 15°$	**3.** $\mu m_2 g \cos\theta$
S. $\theta = 20°$	**4.** $\mu(m_1 + m_2) g \cos\theta$

Code:
(A) P-1, Q-1, R-1, S-3
(B) P-2, Q-2, R-2, S-3
(C) P-2, Q-2, R-2, S-4
(D) P-2, Q-2, R-3, S-3

14. A uniform wooden stick of mass 1.6 kg and length ● rests in an inclined manner on a smooth, vertical wall of height *h* (●) such that a small portion of the stick extends beyond the wall. The reaction force of the wall on the stick is perpendicular to the stick. The stick makes an angle of 30° with the wall and the bottom of the stick is on a rough floor. The reaction of the wall on the stick is equal in magnitude to the reaction of the floor on the stick. The ratio *h*/● and the frictional force *f* at the bottom of the stick are (g = 10 ms^{-2}) **[IIT-JEE-2016]**

(A) $\frac{h}{1} = \frac{\sqrt{3}}{16}, f = \frac{16\sqrt{3}}{3} N$ **(B)** $\frac{h}{1} = \frac{3}{16}, f = \frac{16\sqrt{3}}{3} N$

(C) $\frac{h}{1} = \frac{3\sqrt{3}}{16}, f = \frac{8\sqrt{3}}{3} N$ **(D)** $\frac{h}{1} = \frac{3\sqrt{3}}{16}, f = \frac{16\sqrt{3}}{3} N$

15. The position vector $\vec{r}$ of a particle of mass m is given by the following equation $\vec{r}(t) = \alpha t^3 \hat{i} + \beta t^2 \hat{j}$ where $\alpha = 10/3$ m s^{-3}, $\beta = 5$ m s^{-2} and m = 0.1 kg. At t = 1 s, which of the following statement(s) is(are) true about the particle?
[IIT-JEE-2016]
(A) The velocity $\vec{v}$ is given by $\vec{v} = \left(10\hat{i} + 10\hat{j}\right)$ ms^{-1}
(B) The angular momentum $\vec{L}$ with respect to the origin is given by $\vec{L} = -(5/3)\hat{k}$ N m s
(C) The force $\vec{F}$ is given by $\vec{F} = \left(\hat{i} + 2\hat{j}\right)$ N
(D) The torque τ with respect to the origin is given by $\vec{\tau} = -(20/3)\hat{k}$ N m

ASSERTION – REASON

This question contains, statement I (assertion) and statement II (reason).

16. **Statement–I :** A cloth covers a table. Some dishes are kept on it. The cloth can be pulled out without dislodging the dishes from the table. **[IIT-JEE 2007]**

Statement–II : For every action there is an equal and opposite reaction.

(A) statement–I is true, statement–II is true; statement–II is a correct explanation for statement–I
(B) statement–I is true, statement–II is true, statement–II is NOT a correct explanation for statement–I
(C) statement–I is true, statement–II is false
(D) statement–I is false, statement–II is true

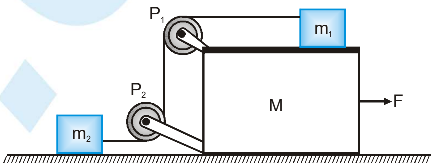
17. **Statement -I :** It is easier to pull a heavy object than to push it on a level ground. **[IIT-JEE 2008]**

Statement-II: The magnitude of frictional force depends on the nature of the two surface in contact.

(A) statement–I is true, statement–II is true; statement–II is a correct explanation for statement–I
(B) statement–I is true, statement–II is true, statement–II is NOT a correct explanation for statement–I
(C) statement–I is true, statement–II is false
(D) statement–I is false, statement–II is true

SUBJECTIVE QUESTIONS

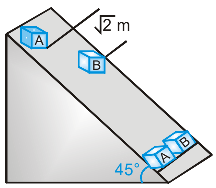
18. In the figure masses m_1, m_2 and M are 20 kg, 5 kg and 50 kg respectively. The coefficient of friction between M and ground is zero. The coefficient of friction between m_1 and M and that between m_2 and ground is 0.3. The pulleys and the strings are massless. The string is perfectly horizontal between P_1 and m_1 and also between P_2 and m_2. The string is perfectly vertical between P_1 and P_2. An external horizontal force F is applied to the mass M. Take g = 10 m/s². **[IIT-JEE 2000]**



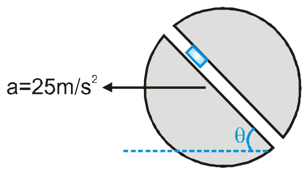
(i) Draw a free body diagram of mass M, clearly showing all the forces.

(ii) Let the magnitude of the force of friction between m_1 and M be f_1 and that between m_2 and ground be f_2. For a particular force F it is found that $f_1 = 2f_2$. Find f_1 and f_2. Write equations of motion of all the masses. Find F, tension in the string and acceleration of the masses.

19. Two blocks A and B of equal masses are release from an inclined plane of of inclination 45° at t = 0. Both the blocks are initially at rest. The coefficient of kinetic friction between the block A and the inclined plane is 0.2 while it is 0.3 for block B. Initially the block A is $\sqrt{2}$ m behind the block B. When and where their front faces will come in a line. (Take g = 10 m/s²) **[IIT-JEE 2004]**



20. A circular disc with a groove along its diameter is placed horizontally. A block of mass 1 kg is placed as shown. The coefficient of friction between the block and all surface of groove in contact is $\mu = \frac{2}{5}$. The disc has an acceleration of 25 m/s². Find the acceleration of the block with respect to disc. **[IIT-JEE 2006]**



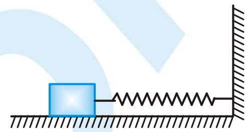
INTEGER TYPE QUESTIONS

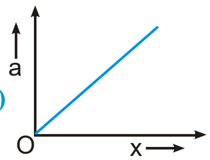
21. A block is moving on an inclined plane making an angle 45° with the horizontal and the coefficient of friction is μ. The force required to just push it up the inclined plane is 3 times the force required to just prevent it from sliding down. If we define N =10μ, then N is **[IIT-JEE-2011]**

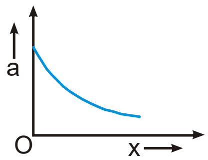
MOCK TEST : NEWTON'S LAW & MOTION

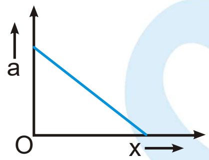
SECTION - I : STRAIGHT OBJECTIVE TYPE

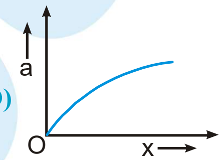
1. A light spring is compressed and placed horizontally between a vertical fixed wall and a block free to slide over a smooth horizontal table top as shown in the figure. The system is released from rest. The graph which represents the relation between the magnitude of acceleration ' a ' of the block and the distance ' x ' travelled by it (as long as the spring is compressed) is:



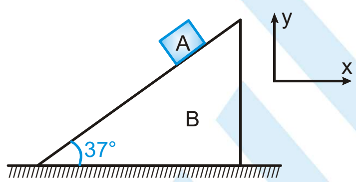
(A) 

(B) 

(C) 

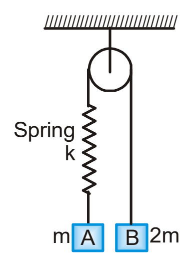
(D) 

2. In the figure shown the acceleration of A is, $\vec{a}_A = 15\hat{i}+15\hat{j}$ then the acceleration of B is: (A remains in contact with B)



(A) $6\hat{i}$ **(B)** $-15\hat{i}$ **(C)** $-10\hat{i}$ **(D)** $-5\hat{i}$

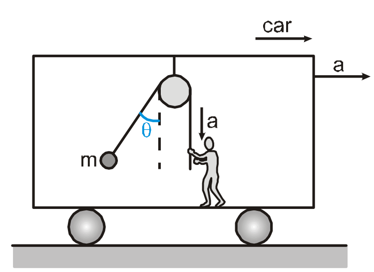
3. Two blocks A and B of masses m & 2m respectively are held at rest such that the spring is in natural length. Find out the accelerations of both the blocks just after release:



(A) $g\downarrow, g\downarrow$ **(B)** $\frac{g}{3}\downarrow, \frac{g}{3}\uparrow$

(C) 0, 0 **(D)** $g\downarrow, 0$

4. A bob is hanging over a pulley inside a car through a string . The second end of the string is in the hand of a person standing in the car . The car is moving with constant acceleration 'a' directed horizontally as shown in figure . Other end of the string is pulled with constant acceleration 'a' vertically downward.
The tension in the string is equal to :



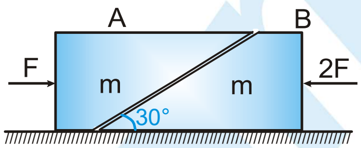
(A) $m\sqrt{g^2+a^2}$ **(B)** $m\sqrt{g^2+a^2} - ma$

(C) $m\sqrt{g^2+a^2} + ma$ **(D)** $m(g+a)$

5. Inside a horizontally moving box, an experimenter finds that when an object is placed on a smooth horizontal table and is released, it moves with an acceleration of 10 m/s^2. In this box if 1 kg body is suspended with a light string, the tension in the string in equilibrium position. (w.r.t. experimenter) will be. (Take g = 10 m/s^2)

(A) 10 m/s^2. **(B)** $10\sqrt{2}$ m/s^2. **(C)** 20 m/s^2. **(D)** zero

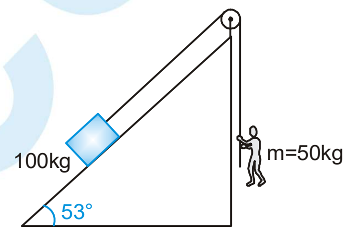
6. Two blocks 'A' and 'B' each of mass 'm' are placed on a smooth horizontal surface. Two horizontal force F and 2F are applied on both the blocks 'A' and 'B' respectively as shown in figure. The block A does not slide on block B. Then the normal reaction acting between the two blocks is :



(A) F **(B)** F/2 **(C)** $\frac{F}{\sqrt{3}}$ **(D)** 3F

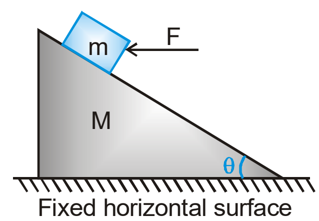
7. In the arrangement shown, by what acceleration the boy must go up so that 100 kg block remains stationary on the wedge. The wedge is fixed and friction is absent everywhere.

(Take g = 10 m/s^2)



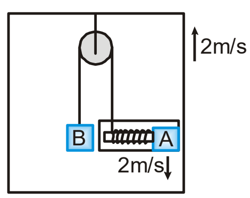
(A) 2 m/s^2 **(B)** 4 m/s^2
(C) 6 m/s^2 **(D)** 8 m/s^2

8. A block of mass m lies on wedge of mass M, which lies on fixed horizontal surface. The wedge is free to move on the horizontal surface. A horizontal force of magnitude F is applied on block as shown, neglecting friction at all surfaces, the value of force F such that block has no relative motion w.r.t. wedge will be : (where g is acceleration due to gravity)



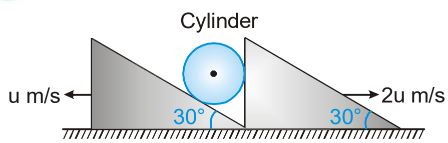
(A) $(M + m)\ g \tan\theta$ **(B)** $(M + m)\ g \cot\theta$ **(C)** $\frac{m}{M}(M + m)\ g \tan\theta$ **(D)** $\frac{m}{M}(M + m)\ g \cot\theta$

9. In the figure shown the velocity of lift is 2 m/s while string is winding on the motor shaft with velocity 2 m/s and block A is moving downwards with a velocity of 2 m/s, then find out the velocity of block B.



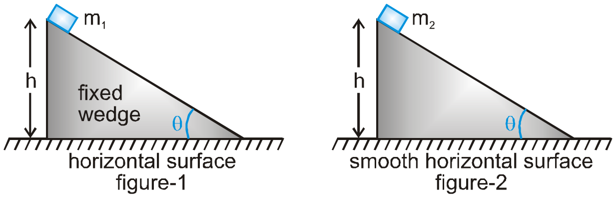
(A) 2 m/s ↑ **(B)** 2 m/s ↓
(C) 4 m/s ↑ **(D)** 8 m/s ↑

10. System is shown in the figure. Assume that cylinder remains in contact with the two wedges. The velocity of cylinder is -



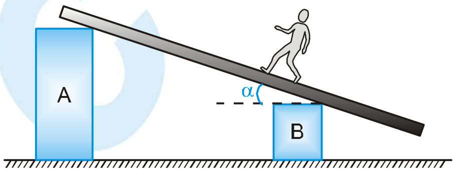
(A) $\sqrt{19 - 4\sqrt{3}}\ \frac{u}{2}$ m/s **(B)** $\frac{\sqrt{13}\,u}{2}$ m/s **(C)** $\sqrt{3}\,u$ m/s **(D)** $\sqrt{7}\,u$ m/s

11. A block of mass m_1 lies on top of fixed wedge as shown in figure-1 and another block of mass m_2 lies on top of wedge which is free to move as shown in figure-2. At time t = 0, both the blocks are released from rest from a vertical height h above the respective horizontal surface on which the wedge is placed as shown. There is no friction between block and wedge in both the figures. Let T_1 and T_2 be the time taken by block in figure-1 and block in figure-2 respectively to just reach the horizontal surface, then :



(A) $T_1 > T_2$ **(B)** $T_1 < T_2$ **(C)** $T_1 = T_2$ **(D)** Data insufficient

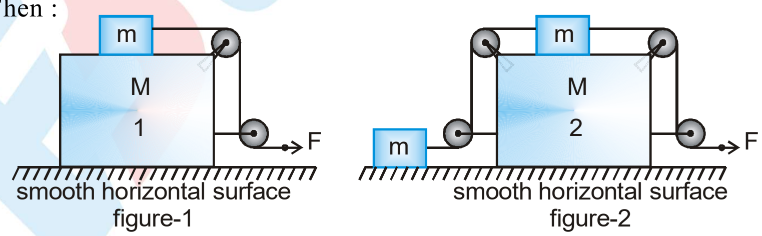
12. A plank is held at an angle α to the horizontal (Fig.) on two fixed supports A and B. The plank can slide against the supports (without friction) because of its weight Mg. Acceleration and direction in which a man of mass m should move so that the plank does not move.



(A) $g \sin\alpha \left(1+\frac{m}{M}\right)$ down the incline **(B)** $g \sin\alpha \left(1+\frac{M}{m}\right)$ down the incline

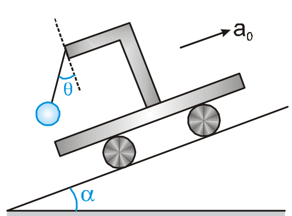
(C) $g \sin\alpha \left(1+\frac{m}{M}\right)$ up the incline **(D)** $g \sin\alpha \left(1+\frac{M}{m}\right)$ up the incline

13. In the situation shown in figure all the string are light and inextensible and pullies are light. There is no friction at any surface and all block are of cuboidal shape. A horizontal force of magnitude F is applied to right most free end of string in both cases of figure 1 and figure 2 as shown. At the instant shown, the tension in all strings are non zero. Let the magnitude of acceleration of large blocks (of mass M) in figure 1 and figure 2 are a_1 and a_2 respectively. Then :



(A) $a_1 = a_2 \neq 0$ **(B)** $a_1 = a_2 = 0$ **(C)** $a_1 > a_2$ **(D)** $a_1 < a_2$

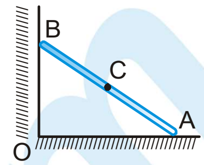
14. A pendulum of mass m hangs from a support fixed to a trolley. The direction of the string when the trolley rolls up a plane of inclination α with acceleration a_0 is



(A) $\theta = \tan^{-1}\alpha$ **(B)** $\theta = \tan^{-1}\left(\frac{a_0}{g}\right)$

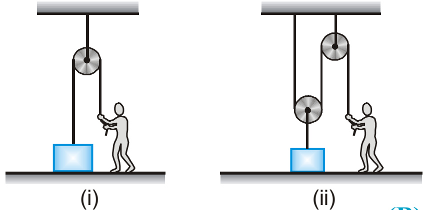
(C) $\theta = \tan^{-1}\left(\frac{g}{a_0}\right)$ **(D)** $\theta = \tan^{-1}\left(\frac{a_0 + g\sin\alpha}{g\cos\alpha}\right)$

15. A rod of length 2● is moving such that its ends A and B move in contact with the horizontal floor and vertical wall respectively as shown in figure. O is the intersection point of the vertical wall and horizontal floor. The velocity vector of the centre of rod C is always directed along tangent drawn at C to the -



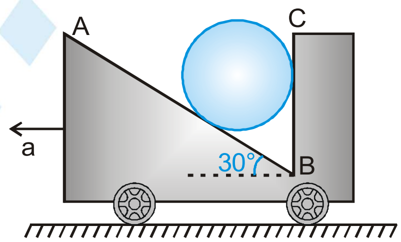
(A) circle of radius $\frac{\lambda}{2}$ whose centre lies at O
(B) circle of radius ● whose centre lies at O
(C) circle of radius 2● whose centre lies at O
(D) None of these

16. In the figure shown, a person wants to raise a block lying on the ground to a height h. In both the cases if time required is same then in which case he has to exert more force. Assume pulleys and strings light.



(A) (i)
(B) (ii)
(C) same in both
(D) Cannot be determined

17. A cylinder rests in a supporting carriage as shown. The side AB of carriage makes an angle 30° with the horizontal and side BC is vertical. The carriage lies on a fixed horizontal surface and is being pulled towards left with an horizontal acceleration '*a*'. The magnitude of normal reactions exerted by sides AB and BC of carriage on the cylinder be N_{AB} and N_{BC} respectively. Neglect friction everywhere. Then as the magnitude of acceleration '*a*' of the carriage is increased, pick up the correct statement:

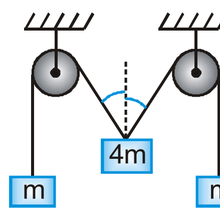


(A) N_{AB} increases and N_{BC} decreases.
(B) Both N_{AB} and N_{BC} increase.
(C) N_{AB} remains constant and N_{BC} increases.
(D) N_{AB} increases and N_{BC} remains constant.

18. A car is moving on a plane inclined at 30° to the horizontal with an acceleration of 9.8 m/s^2 parallel to the plane upward. A bob is suspended by a string from the roof. The angle in degrees which the string makes with the vertical is : (Assume that the bob does not move relative to car) [g = 9.8 m/s^2]

(A) 20°
(B) 30°
(C) 45°
(D) 60°

19. In the figure shown, the pulleys and strings are massless. The acceleration of the block of mass 4m just after the system is released from rest is ($\theta = \sin^{-1}\frac{3}{5}$)



(A) $\frac{2g}{5}$ downward

(B) $\frac{2g}{5}$ upwards

(C) $\frac{5g}{11}$ upwards

(D) $\frac{5g}{11}$ downwards

20. Five persons A, B, C, D & E are pulling a cart of mass 100 kg on a smooth surface and cart is moving with acceleration $3\ m/s^2$ in east direction. When person 'A' stops pulling, it moves with acceleration $1 m/s^2$ in the west direction. When person 'B' stops pulling, it moves with acceleration $24\ m/s^2$ in the north direction. The magnitude of acceleration of the cart when only A & B pull the cart keeping their directions same as the old directions, is :

(A) $26\ m/s^2$ **(B)** $3\sqrt{71}\ m/s^2$ **(C)** $25\ m/s^2$ **(D)** $30\ m/s^2$

21. A body of mass 32 kg is suspended by a spring balance from the roof of a vertically operating lift and going downward from rest. At the instants the lift has covered 20 m and 50 m, the spring balance showed 30 kg & 36 kg respectively. The velocity of the lift is:

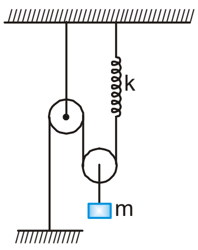
(A) decreasing at 20 m & increasing at 50 m

(B) increasing at 20 m & decreasing at 50 m

(C) continuously decreasing at a constant rate through the journey

(D) continuously increasing at constant rate through out the journey

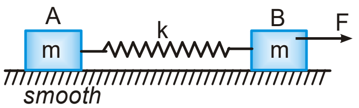
22. Mass m shown in the figure is in equilibrium. If it is displaced further by x and released find its acceleration just after it is released. Take pulleys to be light & smooth and strings light.



(A) $\frac{4kx}{5m}$ **(B)** $\frac{2kx}{5m}$

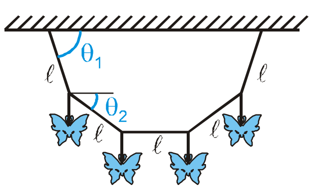
(C) $\frac{4kx}{m}$ **(D)** none of these a

23. Initially the spring is undeformed. Now the force 'F' is applied to 'B' as shown in the figure . When the displacement of 'B' w.r.t. 'A' is 'x' towards right in some time then the relative acceleration of 'B' w.r.t. 'A' at that moment is:



(A) $\frac{F}{2\ m}$ **(B)** $\frac{F - kx}{m}$ **(C)** $\frac{F - 2\ kx}{m}$ **(D)** none of these

24. Four identical metal butterflies are hanging from a light string of length 5● at equally placed points as shown in the figure . The ends of the string are attached to a horizontal fixed support. The middle section of the string is horizontal. The relation between the angle θ_1 and θ_2 is given by



(A) $\sin\theta_1 = 2\sin\theta_2$

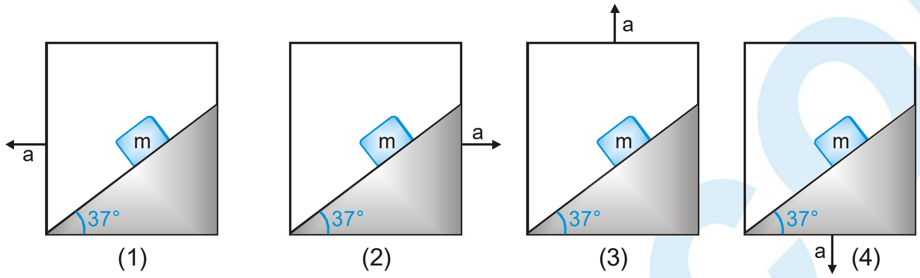
(B) $2\cos\theta_1 = \sin\theta_2$

(C) $\tan\theta_1 = 2\tan\theta_2$

(D) $\theta_2 < \theta_1$ and no other conclusion can be derived.

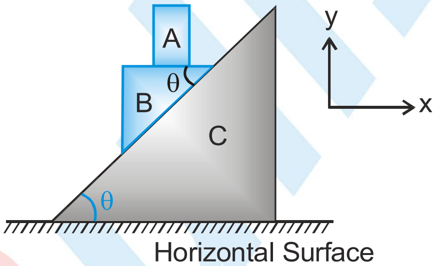
SECTION - II : MULTIPLE CORRECT ANSWER TYPE

25. A block of mass m is placed on a wedge. The wedge can be accelerated in four manners marked as **(1)**, **(2)**, **(3)** and **(4)** as shown. If the normal reactions in situation **(1)**, **(2)**, **(3)** and **(4)** are N_1, N_2, N_3 and N_4 respectively and acceleration with which the block slides on the wedge in situations are b_1, b_2, b_3 and b_4 respectively then:



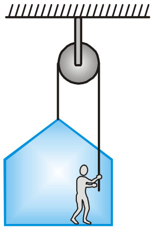
(A) $N_3 > N_1 > N_2 > N_4$ **(B)** $N_4 > N_3 > N_1 > N_2$ **(C)** $b_2 > b_3 > b_4 > b_1$ **(D)** $b_2 > b_3 > b_1 > b_4$

26. In the figure shown all the surface are smooth. All the blocks A, B and C are movable, x-axis is horizontal and y-axis vertical as shown. Just after the system is released from the position as shown.



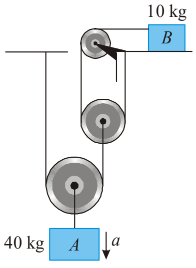
(A) Acceleration of 'A' relative to ground is in negative y-direction
(B) Acceleration of 'A' relative to B is in positive x-direction
(C) The horizontal acceleration of 'B' relative to ground is in negative x-direction.
(D) The acceleration of 'B' relative to ground directed along the inclined surface of 'C' is greater than g sin θ.

27. A painter is applying force himself to raise him and the box with an acceleration of 5 m/s^2 by a massless rope and pulley arrangement as shown in figure. Mass of painter is 100 kg and that of box is 50 kg. If g = 10 m/s^2, then:



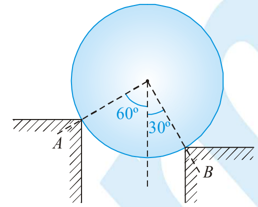
(A) tension in the rope is 1125 N
(B) tension in the rope is 2250 N
(C) force of contact between the painter and the floor is 375 N
(D) none of these

28. Figure shows two blocks A and B connected to an ideal pulley string system. In this system when bodies are released then : (neglect friction and take g = 10 m/s^2)



(A) Acceleration of block A is 1 m/s^2
(B) Acceleration of block A is 2 m/s^2
(C) Tension in string connected to block B is 40 N
(D) Tension in string connected to block B is 80 N

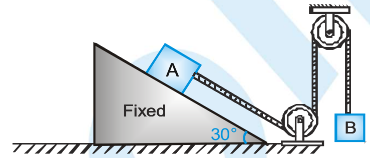
29. A cylinder of mass M and radius R is resting on two corner edges A and B as shown in the figure . The normal reaction at the edges A and B are : (Neglect friction)



(A) $N_A = \sqrt{2} N_B$ **(B)** $N_B = \sqrt{3} N_A$

(C) $N_A = \frac{Mg}{2}$ **(D)** $N_B = \frac{2\sqrt{3}Mg}{5}$

30. Two blocks A and B of equal mass m are connected through a massless string and arranged as shown in the figure . The wedge is fixed on horizontal surface. Friction is absent everywhere. When the system is released from rest.

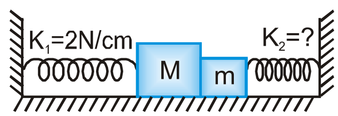


primary position

(A) tension in string is $\frac{mg}{2}$ **(B)** tension in string is $\frac{mg}{4}$

(C) acceleration of A is g/2 **(D)** acceleration of A is $\frac{3}{4}g$

31. Two blocks of mass M and m, are used to compress two different massless springs as shown in the figure. The left spring is compressed by 3 cm, while the right spring is compressed by an unknown amount. The system is at rest and all contact surfaces are smooth. Which of the following statements are true ?

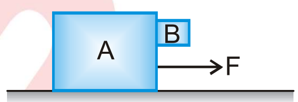


smooth horizontal surface

(A) The force exerted on block of mass m by the right spring is 6 N to the left.
(B) The force exerted on block of mass m by the right spring is impossible to determine.
(C) The net force on block of mass m is zero.
(D) The normal force exerted by block of mass m on block of mass M is 6 N.

SECTION - III : ASSERTION AND REASON TYPE

32. **Statement-1 :** Block A is moving on horizontal surface towards right under action of force F . All surfaces are smooth. At the instant shown the force exerted by block A on block B is equal to net force on block B.



Statement-2 : From Newton's third law, the force exerted by block A on B is equal in magnitude to force exerted by block B on A.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

33. **Statement-1 :** A man standing in a lift which is moving upward, will feel his weight to be greater than when the lift was at rest.
Statement-2 : If the acceleration of the lift is 'a' upward, then the man of mass m shall feel his weight to be equal to normal reaction (N) exerted by the lift given by N = m(g+a) (where g is acceleration due to gravity)
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

34. **STATEMENT–1 :** According to the Newton's third law of motion, the magnitude of the action and reaction force in an action reaction pair is same only in an inertial frame of reference.

STATEMENT–2 : Newton's laws of motion are applicable in every inertial reference frame.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

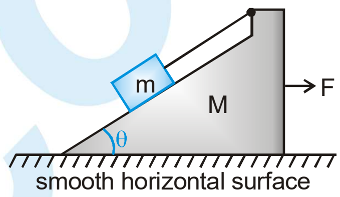
(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True.

SECTION - IV : COMPREHENSION TYPE

Comprehension # 1

A light inextensible string connects a block of mass m and top of wedge of mass M. The string is parallel to inclined surface and the inclined surface makes an angle θ with horizontal as shown in the figure. All surfaces are smooth. Now a constant horizontal force of minimum magnitude F is applied to wedge towards right such that the normal reaction on block exerted by wedge just becomes zero.



35. The magnitude of acceleration of wedge is

(A) g tanθ **(B)** g cotθ **(C)** g sinθ **(D)** g cosθ

36. The magnitude of tension in string is

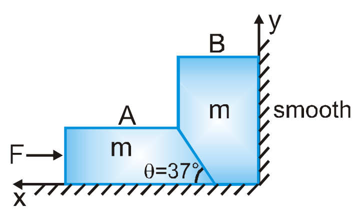
(A) mg secθ **(B)** mg cosecθ **(C)** mg tanθ **(D)** mg cotθ

37. The magnitude of net horizontal force on wedge is :

(A) Mg cotθ **(B)** (M + m)g secθ **(C)** (M + m)g cotθ **(D)** Mg cosecθ

Comprehension # 2

Two smooth blocks are placed at a smooth corner as shown in the figure. Both the blocks are having mass m. We apply a force F on the small block m. Block A presses the block B in the normal direction, due to which pressing force on vertical wall will increase, and pressing force on the horizontal wall decrease, as we increase F. (θ = 37° with horizontal). As soon as the pressing force on the horizontal wall by block B becomes zero, it will loose the contact with the ground. If the value of F is further increased, the block B will accelerate in upward direction and simultaneously the block A will move toward right.



38. What is minimum value of F, to lift block B from ground :

(A) $\frac{25}{12}$ mg **(B)** $\frac{5}{4}$ mg **(C)** $\frac{3}{4}$ mg **(D)** $\frac{4}{3}$ mg

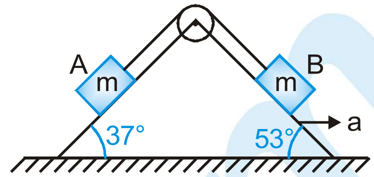
39. If both the blocks are stationary, the force exerted by ground on block A is :

(A) $mg + \frac{3F}{4}$ **(B)** $mg - \frac{3F}{4}$ **(C)** $mg + \frac{4F}{3}$ **(D)** $mg - \frac{4F}{3}$

40. If acceleration of block A is a rightward, then acceleration of block B will be :

(A) $\frac{3a}{4}$ upwards **(B)** $\frac{4a}{3}$ upwards **(C)** $\frac{3a}{5}$ upwards **(D)** $\frac{4a}{5}$ upwards

Comprehension # 3



Two blocks A and B of equal masses m kg each are connected by a light thread, which passes over a massless pulley as shown in the figure. Both the blocks lie on wedge of mass m kg. Assume friction to be absent everywhere and both the blocks to be always in contact with the wedge. The wedge lying over smooth horizontal surface is pulled towards right with constant acceleration a (m/s^2). (g is acceleration due to gravity).

41. Normal reaction (in N) acting on block B is

(A) $\frac{m}{5}(3g+4a)$ **(B)** $\frac{m}{5}(3g-4a)$ **(C)** $\frac{m}{5}(4g+3a)$ **(D)** $\frac{m}{5}(4g-3a)$

42. Normal reaction (in N) acting on block A.

(A) $\frac{m}{5}(3g+4a)$ **(B)** $\frac{m}{5}(3g-4a)$ **(C)** $\frac{m}{5}(4g+3a)$ **(D)** $\frac{m}{5}(4g-3a)$

43. The maximum value of acceleration a (in m/s^2) for which normal reactions acting on the block A and block B are nonzero.

(A) $\frac{3}{4}g$ **(B)** $\frac{4}{3}g$ **(C)** $\frac{3}{5}g$ **(D)** $\frac{5}{3}g$

SECTION - V : MATRIX - MATCH TYPE

44. Column-I gives four different situations involving two blocks of mass m_1 and m_2 placed in different ways on a smooth horizontal surface as shown. In each of the situations horizontal forces F_1 and F_2 are applied on blocks of mass m_1 and m_2 respectively and also $m_2F_1 < m_1F_2$. Match the statements in column I with corresponding results in column-II.

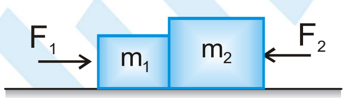
Column I

(A) 

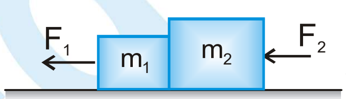
. Both the blocks are connected by massless inelastic string. The magnitude of tension in the string is

(B) 

. Both the blocks are connected by massless inelastic string. The magnitude of tension in the string is

(C) 

. The magnitude of normal reaction between the blocks is

(D) 

. The magnitude of normal reaction between the blocks is

Column II

(p) $\frac{m_1 m_2}{m_1+m_2}\left(\frac{F_1}{m_1}-\frac{F_2}{m_2}\right)$

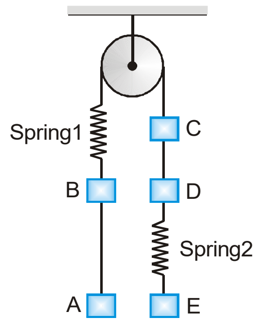
(q) $\frac{m_1 m_2}{m_1+m_2}\left(\frac{F_1-F_2}{m_1+m_2}\right)$

(r) $\frac{m_1 m_2}{m_1+m_2}\left(\frac{F_2}{m_2}-\frac{F_1}{m_1}\right)$

(s) $m_1 m_2\left(\frac{F_1+F_2}{m_1+m_2}\right)$

(t) $\frac{m_1 m_2}{m_1+m_2}\left(\frac{F_1}{m_1}+\frac{F_2}{m_2}\right)$

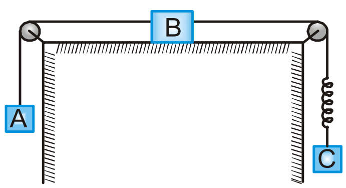
45. The system shown below is initially in equilibrium. Masses of the blocks A,B,C,D and E are respectively 3m, 3m, 2m, 2m and 2m. Match the conditions in column-I with the effects in column-II .



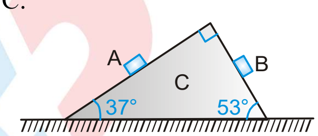
Column-I	Column-II
(A) After spring 2 is cut, tension in string AB	**(p)** increases
(B) After spring 2 is cut,tension in string CD	**(q)** decreases
(C) After string between C and pulley is cut, tension in string AB	**(r)** decreases and then increases
(D) After string between C and pulley is cut, tension in string CD	**(s)** zero
	(t) remain constant

SECTION - VI : INTEGER TYPE

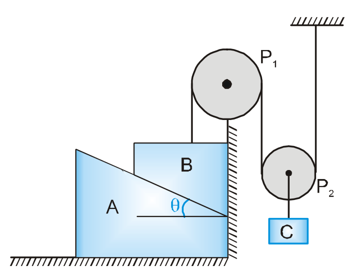
46. In the figure shown all the contacts are smooth. Strings and spring are light. Initially 'A' is held by someone and 'B' and 'C' are at rest and in equilibrium also. Find out the acceleration of block C in m/s^2 just after the block 'A' is released. Masses of A, B and C are M, M and 2M respectively.



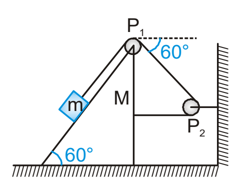
47. In the figure shown blocks 'A' and 'B' are kept on a wedge 'C'. A, B and C each have mass m. All surfaces are smooth. Find the acceleration of C.



48. In the figure shown P_1 and P_2 are massless pulleys. P_1 is fixed and P_2 can move. Masses of A, B and C are $\frac{9m}{64}$, 2m and m respectively . All contacts are smooth and the string is massless. $\theta = \tan^{-1}\left(\frac{3}{4}\right)$. Find the acceleration of block C in m/s^2.



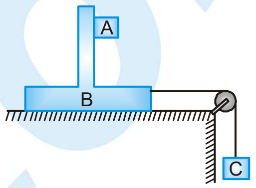
49. In the arrangement shown in the Fig., a block of mass m = 2 kg lies on a wedge of mass M = 8 kg. The initial acceleration of the wedge (if the surfaces are smooth) given by $\frac{3\sqrt{3}g}{x}$ m/s^2 then x is.



MOCK TEST : FRICTION

SECTION - I : STRAIGHT OBJECTIVE TYPE

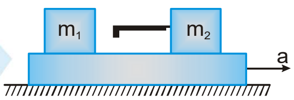
1. In the arrangement shown in the figure mass of the block B and A are 2 m, 8 m respectively. Surface between B and floor is smooth. The block B is connected to block C by means of a pulley. If the whole system is released then the minimum value of mass of the block C so that the block A remains stationary with respect to B is : (Co-efficient of friction between A and B is m.)



(A) $\dfrac{m}{\mu}$ **(B)** $\dfrac{2m}{\mu+1}$

(C) $\dfrac{10\ m}{1-\mu}$ **(D)** $\dfrac{10m}{\mu-1}$

2. Two block of masses m_1 and m_2 are connected with a massless unstretched spring and placed over a plank moving with an acceleration 'a' as shown in figure. The coefficient of friction between the blocks and platform is μ.



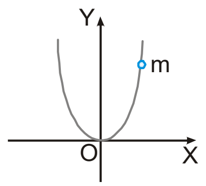
(A) spring will be stretched if $a > \mu g$

(B) spring will be compressed if $a \le \mu g$

(C) spring will neither be compressed nor be stretched for $a \le \mu g$

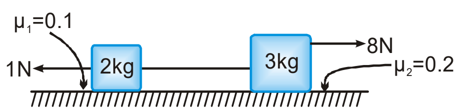
(D) spring will be in its natural length under all conditions

3. A bead of mass m is located on a parabolic wire with its axis vertical and vertex directed towards downward as in figure and whose equation is $x^2 = ay$. If the coefficient of friction is μ, the highest distance above the x-axis at which the particle will be in equilibrium is



(A) μa **(B)** $\mu^2 a$ **(C)** $\dfrac{1}{4}\mu^2 a$ **(D)** $\dfrac{1}{2}\mu a$

4. In the shown arrangement if f_1, f_2 and T be the frictional forces on 2 kg block, 3kg block & tension in the string respectively, then their values are:



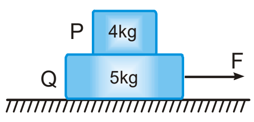
(A) 2 N, 6 N, 3.2 N

(B) 2 N, 6 N, 0 N

(C) 1 N, 6 N, 2 N

(D) data insufficient to calculate the required values.

5. The coefficient of friction between 4kg and 5 kg blocks is 0.2 and between 5 kg block and ground is 0.1 respectively. Choose the correct statement:



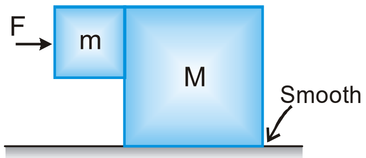
(A) Minimum force needed to cause system to move is 17 N

(B) When force is 4N static friction at all surfaces is 4N to keep system at rest

(C) Maximum acceleration of 4kg block is $2 m/s^2$

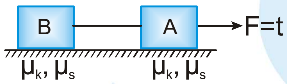
(D) Slipping between 4kg and 5 kg blocks start when F is 17N

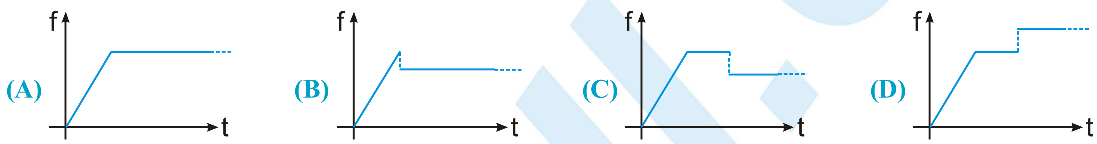
6. The two blocks, m = 10 kg and M = 50 kg are free to move as shown. The coefficient of static friction between the blocks is 0.5 and there is no friction between M and the ground. A minimum horizontal force F is applied to hold m against M that is equal to :



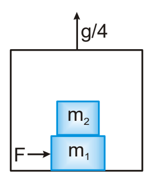
(A) 100 N **(B)** 50 N **(C)** 240 N **(D)** 180 N

7. A force F = t is applied to a block A as shown in figure, where t is time in seconds. The force is applied at t = 0 seconds when the system was at rest. Which of the following graph correctly gives the frictional force between A and horizontal surface as a function of time t.[Assume that at t = 0, tension in the string connecting the two blocks is zero].





8. A plank of mass m_1 = 8 kg with a bar of mass m_2 = 2 kg placed on its rough surface, lie on a smooth floor of elevator ascending with an acceleration g/4. The coefficient of friction is μ = 1/5 between m_1 and m_2 . A horizontal force F = 30 N is applied to the plank. Then the acceleration of bar and the plank in the reference frame of elevator are:

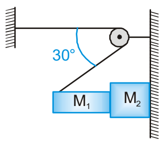


(A) 3.5 m/s^2, 5 m/s^2 **(B)** 5 m/s^2, $\frac{50}{8}$ m/s^2

(C) 2.5 m/s^2, $\frac{25}{8}$ m/s^2 **(D)** 4.5 m/s^2, 4.5m/s^2

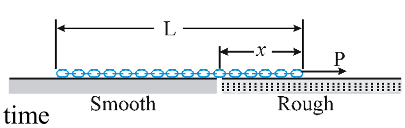
9. A block of mass 1 kg lies on a horizontal surface in a truck. The coefficient of static friction between the block and the surface is 0.6 If the acceleration of the truck is 5 m/s^2, the frictional force acting on the block is :
(A) 5 N **(B)** 6 N **(C)** 10 N **(D)** 15 N

10. Two blocks with masses M_1 and M_2 of 10 kg and 20 kg respectively are placed as in fig. μ_s = 0.2 between all surfaces, then tension in string and acceleration of M_2 block will be :



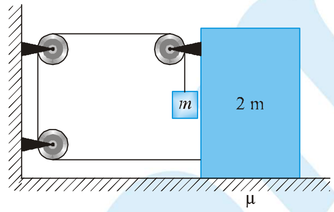
(A) 250 N, 3 m/s^2 **(B)** 200 N, 6 m/s^2
(C) 306 N, 4.7 m/s^2 **(D)** 400 N, 6.5 m/s^2

11. A chain of length L is placed on a horizontal surface as shown in figure. At any instant x is the length of chain on rough surface and the remaining portion lies on smooth surface. Initially x = 0. A horizontal force P is applied to the chain (as shown in the figure). In the duration x changes from x = 0 to x = L, for chain to move with constant speed:



(A) the magnitude of P should increase with time
(B) the magnitude of P should decrease with time
(C) the magnitude of P should increase first and then decrease with time
(D) the magnitude of P should decrease first and then increase with time

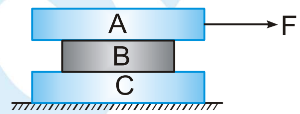
12. In the system shown in figure the friction coefficient between ground and bigger block is μ. There is no friction between both the blocks. The string connecting both the block is light; all three pulleys are light and frictionless. Then the minimum limiting value of μ so that the system remains in equilibrium is



(A) $\frac{1}{2}$ (B) $\frac{1}{3}$

(C) $\frac{2}{3}$ (D) $\frac{3}{2}$

13. Given $m_A = 20$ kg, $m_B = 10$ kg, $m_C = 20$ kg. Between A and B $\mu_1 = 0.3$, between B and C $\mu_2 = 0.3$ and between C and ground $\mu_3 = 0.1$. The least horizontal force F to start the motion of any part of the system of three blocks resting upon one another as shown in figure is ($g = 10$ m/s^2)



(A) 60 N (B) 90 N (C) 80 N (D) 50 N

14. A 1.5 kg box is initially at rest on a horizontal surface when at t = 0 a horizontal force $\vec{F} = (1.8t)\hat{i}\,N$ (with t in seconds), is applied to the box. The acceleration of the box as a function of time t is given by :

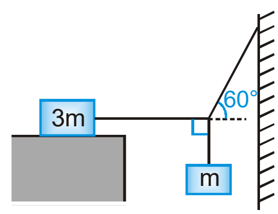
$\vec{a} = 0$ for $0 \le t \le 2.85$

$\vec{a} = (1.2t - 2.4)\hat{i}$ m/s^2 for $t > 2.85$

The coefficient of kinetic friction between the box and the surface is :

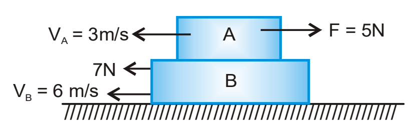
(A) 0.12 (B) 0.24 (C) 0.36 (D) 0.48

15. A mass *m* is supported as shown in the figure by ideal strings connected to a rigid wall and to a mass 3*m* at rest on a fixed horizontal surface. The string connected to larger mass is horizontal, that connected to smaller mass is vertical and the one connected to wall makes an angle 60° with horizontal. Then the minimum coefficient of static friction between the larger mass and the horizontal surface that permits the system to remain in equilibrium in the situation shown is:



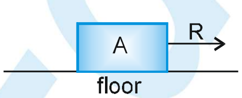
(A) $\frac{1}{\sqrt{3}}$ (B) $\frac{1}{3\sqrt{3}}$ (C) $\frac{\sqrt{3}}{2}$ (D) $\sqrt{\frac{3}{2}}$

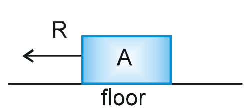
16. In the following figure, find the direction of friction on the blocks and ground respectively .

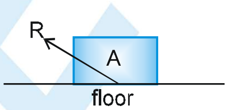


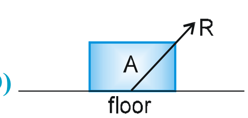
(A) Block A (left), block B(right due to block A, right due to ground)
(B) Block A (right), block B(left due to block A, left due to ground)
(C) Block A (right), block B(left due to block A, right due to ground)
(D) Block A (left), block B(left due to block A, left due to ground)

17. A box 'A' is lying on the horizontal floor of the compartment of a train running along horizontal rails from left to right. At time 't', it decelerates. Then the reaction R by the floor on the box is given best by :

(A) 

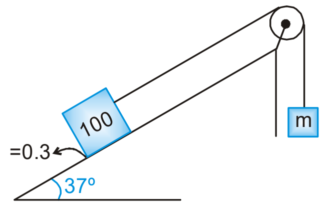
(B) 

(C) 

(D) 

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

18. The value of mass m for which the 100 kg block remains in static equilibrium is



(A) 35 kg **(B)** 37 kg **(C)** 83 kg **(D)** 85 kg

19. The force F_1 that is necessary to move a body up an inclined plane is double the force F_2 that is necessary to just prevent it from sliding down, then :

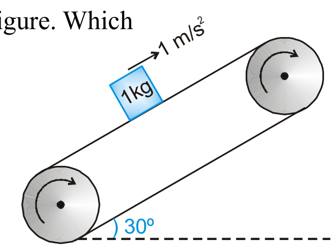
(A) $F_2 = w \sin(\theta - \phi) \sec\phi$ **(B)** $F_1 = w \sin(\theta - \phi) \sec\phi$
(C) $\tan\phi = 3\tan\theta$ **(D)** $\tan\theta = 3\tan\phi$

Where ϕ = angle of friction
θ = angle of inclined plane
w = weight of the body

20. A block A (5 kg) rests over another block B (3 kg) placed over a smooth horizontal surface. There is friction between A and B. A horizontal force F_1 gradually increasing from zero to a maximum is applied to A so that the blocks move together without relative motion. Instead of this another horizontal force F_2, gradually increasing from zero to a maximum is applied to B so that the blocks move together without relative motion. Then

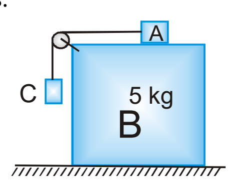
(A) F_1 (max) = F_2 (max) **(B)** F_1 (max) > F_2 (max)
(C) F_1 (max) < F_2 (max) **(D)** F_1 (max): F_2 (max) = 5: 3

21. A block of mass 1 kg is stationary with respect to a conveyer belt that is accelerating with 1 m/s^2 upwards at an angle of 30° as shown in figure. Which of the following is/are correct?



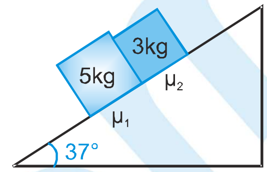
(A) Force of friction on block is 6 N upwards.
(B) Force of friction on block is 1.5 N upwards.
(C) Contact force between the block & belt is 10.5 N.
(D) Contact force between the block & belt is $5\sqrt{3}$ N.

22. All the blocks shown in the figure are at rest. The pulley is smooth and the strings are light. Coefficient of friction at all the contacts is 0.2. A frictional force of 10 N acts between A and B. The block A is about to slide on block B. The normal reaction and frictional force exerted by the ground on the block B is.



(A) The normal reaction exerted by the ground on the block B is 110N
(B) The normal reaction exerted by the ground on the block B is 50 N
(C) The frictional force exerted by the ground on the block B is 20N
(D) The frictional force exerted by the ground on the block B is zero

23. Two blocks of masses 5 kg and 3kg are placed in contact over an inclined surface of angle 37°, as shown. μ_1 is friction coefficient between 5kg block and the surface of the incline and similarly, μ_2 is friction coefficient between the 3kg block and the surface of the incline. After the release of the blocks from the inclined surface,



(A) if $\mu_1 = 0.5$ and $\mu_2 = 0.3$ then 5 kg block exerts 3N force on the 3 kg block

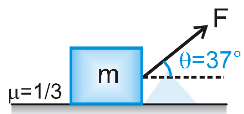
(B) if $\mu_1 = 0.5$ and $\mu_2 = 0.3$ then 5 kg block exerts 8 N force on the 3 kg block

(C) if $\mu_1 = 0.3$ and $\mu_2 = 0.5$ then 5 kg block exerts 1 N force on the 3kg block.

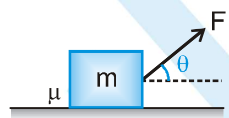
(D) if $\mu_1 = 0.3$ and $\mu_2 = 0.5$ then 5 kg block exerts no force on the 3kg block.

SECTION - III : ASSERTION AND REASON TYPE

24. **Statement-1 :** A block of mass m is placed at rest on rough horizontal surface. The coefficient of friction between the block and horizontal surface is $\mu = 1/3$. The minimum force F applied at angle $\theta = 37°$ (as shown in figure) to pull the block horizontally is not equal to μmg. (Take $\sin 37° = \frac{3}{5}, \cos 37° = \frac{4}{5}$)



Statement-2 : For a block of mass m placed on rough horizontal surface, the minimum horizontal force required to pull the block is μmg. The minimum force F applied at angle θ (as shown in figure) to pull the block horizontally may be less than μmg. (Where μ is co-efficient of friction).



(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

25. **Statement-1 :** A body is lying at rest on a rough horizontal surface. A person accelerating with acceleration $a\hat{i}$ (where a is positive constant and $\hat{i}$ is a unit vector in horizontal direction) observes the body. With respect to him, the block experiences a kinetic friction.

Statement-2 : Whenever there is relative motion between the contact surfaces then kinetic friction acts.

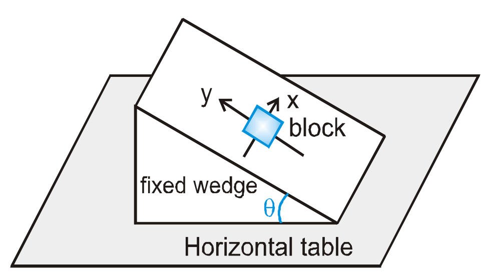
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

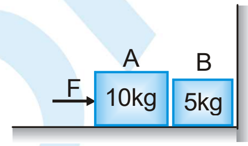
26. **Statement-1 :** A fixed wedge of inclination θ lies on horizontal table. x and y axes are drawn on inclined surface as shown, such that x axis is horizontal and y-axis is along line of greatest slope. A block of mass m is placed (at rest) on inclined surface at origin. The coefficient of friction between block and wedge is μ, such that $\tan\theta = \mu$. Then a force $F > \mu mg \cos\theta$ applied to block parallel to inclined surface and along x-axis can move the block along x-axis.



Statement-2 : To move the block placed at rest on rough inclined surface along the inclined surface, the net force on block (except frictional force) should be greater than μN. (N = normal reaction on block).
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

SECTION - IV : COMPREHENSION TYPE

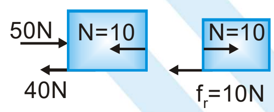
Comprehension # 1



Two bodies A and B of masses 10 kg and 5 kg are placed very slightly separated as shown in figure. The coefficients of friction between the floor and the blocks are as $\mu_s = \mu_k = 0.4$. Block A is pushed by an external force F. The value of F can be changed. When the welding between block A and ground breaks, block A will start pressing block B and when welding of B also breaks, block B will start pressing the vertical wall –

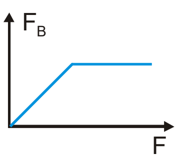
27. If F = 20 N, with how much force does block A presses the block B
(A) 10 N **(B)** 20 N **(C)** 30 N **(D)** Zero

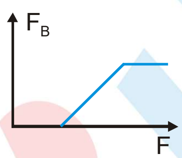
28. If F = 50 N, the friction force acting between block B and ground will be :

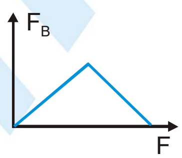


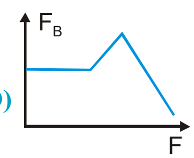
(A) 10 N **(B)** 20 N **(C)** 30 N **(D)** None

29. The force of friction acting on B varies with the applied force F according to curve :

(A)


(B)


(C)


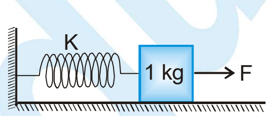
(D)


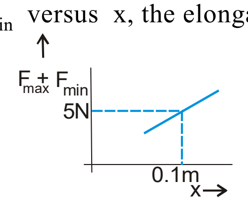
Comprehension - 2

A block of mass 1 kg is placed on a rough horizontal surface. A spring is attached to the block whose other end is joined to a rigid wall, as shown in the figure. A horizontal force is applied on the block so that it remains at rest while the spring is elongated by x. $x \geq \frac{\mu mg}{k}$. Let F_{max} and F_{min} be the maximum and minimum values of force F for which the block remains in equilibrium. For a particular x,

$F_{max} - F_{min} = 2$ N.

Also shown is the variation of $F_{max} + F_{min}$ versus x, the elongation of the spring.





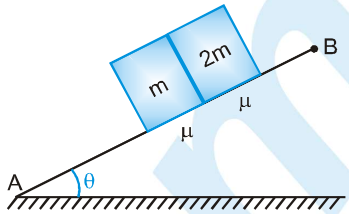
30. The coefficient of friction between the block and the horizontal surface is :
(A) 0.1 **(B)** 0.2 **(C)** 0.3 **(D)** 0.4

31. The spring constant of the spring is:
(A) 25 N/m **(B)** 20 N/m **(C)** 2.5 N/m **(D)** 50 N/m

32. The value of F_{min}, if x = 3 cm is :
(A) 0 **(B)** 0.2N **(C)** 5N **(D)** 1N

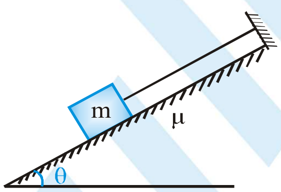
SECTION - V : MATRIX - MATCH TYPE

33. Two blocks of mass m and 2m are slowly just placed in contact with each other on a rough fixed inclined plane as shown. Initially both the blocks are at rest on inclined plane. The coefficient of friction between either block and inclined surface is μ. There is no friction between both the blocks. Neglect the tendency of rotation of blocks on the inclined surface. Column I gives four situation. Column II gives condition under which statements in column I are true. Match the statement in column I with corresponding conditions in column II.



Column I		Column II
(A) The magnitude of acceleration of both blocks are same if	**(p)**	$\mu = 0$
(B) The normal reaction between both the blocks is zero if	**(q)**	$\mu > 0$
(C) The net reaction exerted by inclined surface on each block make same angle with inclined surface (AB) if	**(r)**	$\mu > \tan\theta$
(D) The net reaction exerted by inclined surface on block of mass 2m is double that of net reaction exerted by inclined surface on block of mass m if	**(s)**	$\mu < \tan\theta$
	(t)	$\mu = \tan\theta$

34. A block of mass m is put on a rough inclined plane of inclination θ, and is tied with a light thread shown. Inclination θ is increased gradually from $\theta = 0°$ to $\theta = 90°$. Match the columns according to corresponding curve.



Column I

(A) Tension in the thread versus θ

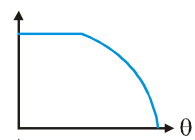
(B) Normal reaction between the block and the incline versus θ

(C) friction force between the block and the incline versus θ

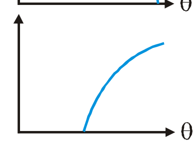
(D) Net interaction force between the block and the incline versus θ

Column II

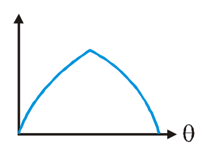
(p)



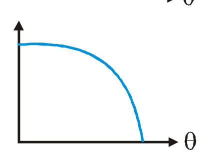
(q)



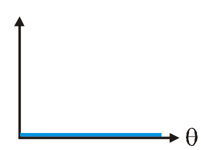
(r)



(s)



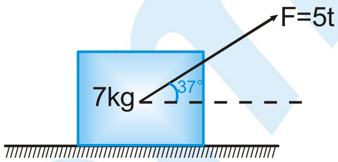
(t)



SECTION - VI : INTEGER TYPE

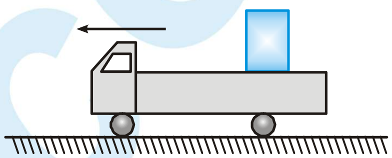
35. A block of 7 kg is placed on a rough horizontal surface and is pulled through a variable force F(in N) = 5t, where 't' is time in second, at an angle of 37° with the horizontal as shown in figure. The coefficient of static friction of the block with the surface is one. If the force starts acting at t = 0 s, Find the time (in sec.) at which the block starts to slide.

(Take $g = 10\ m/s^2$) :



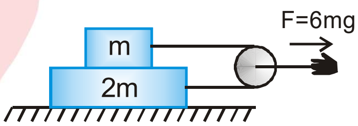
36. The rear side of a truck is open and a box of 40 kg mass is placed 5 m away from the open end as shown. The coefficient of friction between the box & the surface below it is 0.15. On a straight road, the truck starts from rest and accelerates with $2\ ms^{-2}$. At what distance from the starting point does the box fall off the truck (i.e. distance travelled by the truck)?

[Ignore the size of the box]

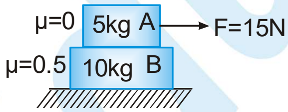


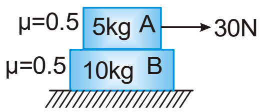
37. A block of mass 5 kg is placed on a rough horizontal surface of a moving compartment . It is seen by an observer sitting inside the compartment, that a force of 10 N is required in horizontal direction to move the box in a direction parallel to the motion of compartment while a force of 20 N is required in horizontal direction to move the box in opposite direction. Find the coefficient of friction between the surface of the block and the surface.

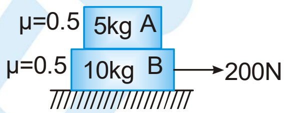
38. A block of mass m is placed on top of a block of mass 2m which in turn is placed on fixed horizontal surface. The coefficient of friction between all surfaces is μ = 1. A massless string is connected to each mass and wraps halfway around a massless and frictionless pulley, as shown in the figure. The pulley is pulled by horizontal force of magnitude F = 6 mg towards right as shown. If the magnitude of acceleration of pulley is $\frac{X}{2}\ m/s^2$, fill the value of X. (Take $g = 10\ m/s^2$)

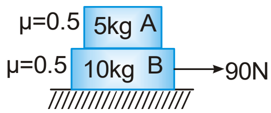


39. Find the accelerations and the friction forces involved value in m/s^2 and N respectively :

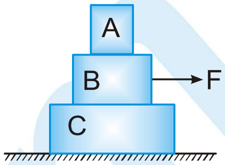
(i) 

(ii) 

(iii) 

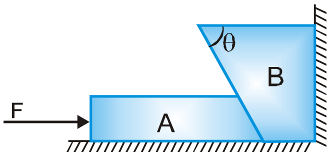
(iv) 

40. In the figure shown, the coefficient of static friction between C and ground is 0.5, coefficient of static friction between A and B is 0.25, coefficient of static friction between B and C is zero. Find the minimum value of force 'F', to cause sliding between A and B. Masses of A, B and C are respectively 2 kg, 4 kg and 5 kg.



41. In the figure shown, the coefficient of static friction between B and the wall is 2/3 and the coefficient of kinetic friction between B and the wall is 1/3. Other contacts are smooth. Find the minimum force 'F' required to lift B, up.

It is $\frac{xmg}{2}$ then x is. Mass of A is 2m and the mass of B is m. Take $\tan\theta = 3/4$.



ANSWER KEY

EXERCISE - 1

1. C **2.** B **3.** B **4.** C **5.** B **6.** B **7.** D **8.** D **9.** A **10.** C **11.** C **12.** B **13.** A
14. D **15.** B **16.** D **17.** D **18.** B **19.** C **20.** D **21.** B **22.** B **23.** C **24.** C **25.** A **26.** A
27. C **28.** A **29.** A **30.** C **31.** C **32.** C **33.** C **34.** A **35.** D **36.** A **37.** A

EXERCISE - 2 : PART # I

1. B **2.** C **3.** B **4.** A **5.** C **6.** C **7.** B **8.** B **9.** C **10.** C **11.** B **12.** B **13.** B
14. D **15.** A **16.** C **17.** A,B,C,D **18.** B,D **19.** C **20.** A,B,D **21.** A,C **22.** D **23.** A,B **24.** D

PART # II

1. C **2.** A **3.** A **4.** A **5.** A **6.** A **7.** A **8.** A **9.** B

EXERCISE - 3 : PART # I

1. (A)-t, (B)-r, (C)-r, (D)-q **2.** (A)-r, (B)-t, (C) -q, (D) -t

PART # II

Comprehension #1 : 1. A 2. C 3. B
Comprehension #2 : 1. B 2. A
Comprehension #3: 1. B 2. D 3. A 4. D
Comprehension #4 : 1. A,D 2. B,C 3. A,B 4. B
Comprehension #5 : 1. B 2. C
Comprehension #6 : 1. B 2. D
Comprehension #7 : 1. B 2. B

EXERCISE - 4

1. 22N, 18N **2.** $(-10\hat{i}-24\hat{j})$ N **3.** $\frac{4mv^2}{\pi d}$ **4.** (i) 20 N (ii) 50 N **5.** (i) 632 N, (ii) 232 N (iii) 392 N, case (a)

6. $\frac{m_1}{m_2}$ **7.** 17.3 N **8.** 14 N **9.** 4.2 kg **10.** 0.5 **11.** $\frac{\mu mg}{\sqrt{1+\mu^2}}$, $\theta = \tan^{-1}(\mu)$ from horizontal **12.** 20N vertically downward

13. For 4 kg a = 2.5 ms^{-2}, For 8 kg a=0 **14.** 15N **15.** $\frac{1}{2}$ s **16.** 5N **17.** 40 to 43 N **18.** 40N

19. $a_A = a_C = \frac{3}{4} g\sin\theta$, $g_B = g\sin\theta$, $T = \frac{m}{2} g\sin\theta$ **20.** $\frac{2g}{23}$

21. (i) $a_A = a_B = \frac{3g}{2}\downarrow$, $a_C = 0$ (ii) $a_A = 2g\uparrow$, $a_B = 2g\downarrow$, $a_C = 0$ (iii) $a_A = a_B = \frac{g}{2}\uparrow$, $a_C = g\downarrow$

22. (i) (A) $a_{m_1} = a_{m_2} = 3.2\,ms^{-2}$ (B) $a_{m_1} = 5.75\,ms^{-2}$, $a_{m_2} = 2\,ms^{-2}$ (ii) $a_{m_1} = 5\,ms^{-2}$, $a_{m_2} = \frac{-10}{3}\,ms^{-2}$

23. (i) 90N (ii) 112.5 N (iii) 150 N **24.** $\theta = \tan^{-1}\left(\frac{1}{3\sqrt{3}}\right)$ **25.** $\mu_s = 0.4$, $\mu_k = 0.3$ **26.** $(1+\sqrt{3})$ ms^{-1} towards left

27. $\frac{25}{24}$ **28.** $\left(1-\frac{\sqrt{3}}{2}\right)$ mg

EXERCISE - 5 : PART # I

1. 1 **2.** 2 **3.** 3 **4.** 1 **5.** 1 **6.** 2 **7.** 4 **8.** 4 **9.** 4 **10.** 3 **11.** 4 **12.** 1 **13.** 1
14. 4 **15.** 1 **16.** 3 **17.** 2 **18.** 3 **19.** 3 **20.** 1 **21.** 4 **22.** 4 **23.** 4 **24.** 3 **25.** 1 **26.** 2

PART # II

MCQ's with one correct answer

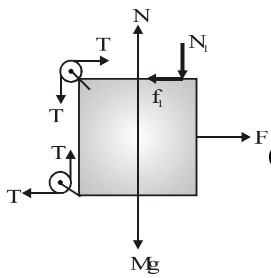
1. A **2.** A **3.** D **4.** C **5.** A **6.** A **7.** A **8.** B **9.** B **10.** A **11.** CD 12. D **13.** D
14. None **15.** ABD

Assertion-Reasoning

16. B **17.** B

Subjective Questions

18. (i)



(ii) 60N, 18N, $\frac{3}{5}$ ms^{-2} **19.** (For A)8 $\sqrt{2}$ m, 2s **20.** 10 ms^{-2}

Integer Type Question

21. 5

MOCK TEST : NEWTON'S LAW & MOTION

1 C **2.** D **3.** A **4.** C **5.** B **6.** D **7.** C **8.** C **9.** D **10.** D **11.** A **12.** B **13.** B
14. D **15.** B **16.** A **17.** C **18.** B **19.** D **20.** C **21.** B **22.** C **23.** C **24.** C **25.** A, C
26. A, B, C, D **27.** A, C **28.** B,D **29.** B,C **30.** B,D **31.** A,C,D **32.** D **33.** D **34** D **35** B
36. B **37.** A **38.** C **39.** C **40.** A **41.** A **42.** D **43.** B **44.** A $\rightarrow$ t ; B $\rightarrow$ r ; C $\rightarrow$ t ; D $\rightarrow$ r
45. A $\rightarrow$ t ; B $\rightarrow$ q ; C $\rightarrow$ s ; D $\rightarrow$ q **46.** (0) **47.** (0) **48.** (3) **49.** (23)

MOCK TEST : FRICTION

1. D **2.** D **3.** C **4.** C **5.** C **6.** C **7.** C **8.** C **9.** A **10.** A **11.** A **12.** C **13.** D
14. B **15.** B **16.** A **17.** C **18.** B,C **19.** A,D **20** B,D **21.** A,C **22.** A,D **23.** A,D **24.** D
25. D **26.** D **27.** D **28.** A **29.** B **30.** A **31.** A **32.** A
33. A $\rightarrow$ P,Q,R,S,T ; B $\rightarrow$ P,Q,R,S,T ; C $\rightarrow$ P,Q,R,S,T ; D $\rightarrow$ P,Q,R,S,T **34.** A $\rightarrow$ Q ; B $\rightarrow$ S; C $\rightarrow$ R; D $\rightarrow$ P
35. (10) **36.** (20) **37.** (3) **38.** (25) **39.** (i) 3 and 0 (ii) 0 and 0 (iii) $a_A = 5\ m/s^2$; $a_B = 10\ m/s^2$; $f_A = 25N$; $f_B = 75N$
(iv) $a_A = 1m/s^2$; $a_B = 1m/s^2$; $f_A = 5N$; $f_B = 75N$ **40.** (15) **41.** (15)