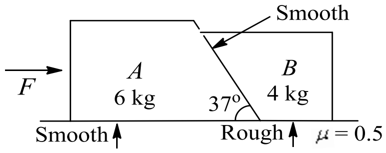
Single Correct Answer Type

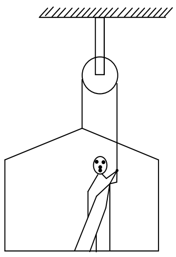
1. Two blocks A of 6 kg and B of 4 kg are placed in contact with each other as shown



There is no friction between A and ground and between both the blocks. Coefficient of friction between B and ground is 0.5. A horizontal force F is applied on$A$. Find the minimum and maximum values of F, which can be applied so that both blocks can move combinely without any relative motion between them

a) 10 N, 50 N b) 12 N, 50 N c) 12 N, 75 N d) None of these

2. A man is raising himself and the crate on which stands with an acceleration of 5 ms^{-2} by a massless rope-and -pulley arrangement. Mass of the man is 100 kg and that of the crate is 50 kg. If $g = 10\ \text{ms}^{-2}$, then the tension in the rope is

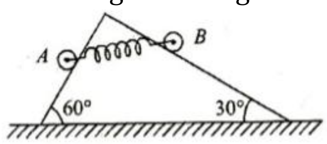


a) 2250 N b) 1125 N c) 750 N d) 375 N

3. A particle has initial velocity$\vec{v} = 3\hat{\imath} + 4\hat{\jmath}$, and a constant force $\vec{F} = 4\hat{\imath} - 3\hat{\jmath}$ acts on the particle. The path of the particle is

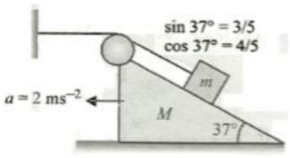
a) Straight line b) Parabolic c) Circular d) Elliptical

4. Two uniform solid cylinders A and B each of mass 1 kg are connected by a spring of constant 200 Nm^{-1} at their axles and are placed on a fixed wedge as shown in the figure. There is no friction between cylinders and wedge. The angle made by the line AB with the horizontal, in equilibrium, is



a) 0° b) 15° c) 30° d) None of these

5. As shown in the figure, if acceleration of M with respect to ground is 2 ms^{-2}, then



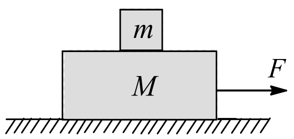
a) Acceleration of m with respect to M is 5 ms^{-2}

b) Acceleration of m with respect to ground is 5 ms^{-2}

c) Acceleration of m with respect M is 2 ms^{-2}

d) Acceleration of m with respect M to ground is 10 ms^{-2}

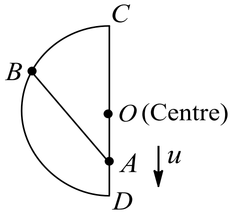
6. A block of mass m is placed on another block of mass$M$, which itself is lying on a horizontal surface. The coefficient of friction between two blocks is μ_1 and that between the block of mass M and horizontal surface isμ_2. What maximum horizontal force can be applied to the lower block so that the two blocks move without separation?



a) $(M+m)(\mu_2-\mu_1)g$ b) $(M-m)(\mu_2-\mu_1)g$ c) $(M-m)(\mu_2+\mu_1)g$ d) $(M+m)(\mu_2+\mu_1)g$

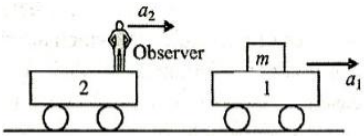
7. A 60 kg man stands on a spring scale in a lift. At some instant, he finds that the scale reading has changed from 60 kg to 50 kg for a while and then comes back to original mark. What should be concluded?
a) The lift was in constant motion upwards
b) The lift was constant motion downwards
c) Lift while in motion downwards suddenly stopped
d) The lift while in motion upwards suddenly stopped

8. Two beads A and B move along a semiconductor wire frame as shown in figure. The beads are connected by an inelastic string which always remains tight. At any instant the speed of A is u, $\angle BAC = 45°$, and $\angle BOC = 75°$, where O is the centre of the semicircular arc. The speed of bead B at that instant is



a) $\sqrt{2}\,u$ b) u c) $\frac{u}{2\sqrt{u}}$ d) $\sqrt{\frac{2}{3}}\,u$

9. Two trolleys 1 and 2 are moving with accelerations a_1 and a_2, respectively, in the same direction. A block of mass m on trolley 1 is in equilibrium from the frame of observer stationary with respect to trolley 2. The magnitude of friction force on block due to trolley is (assume that no horizontal force other than friction force is acting on block)

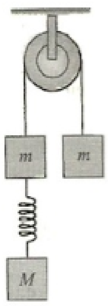


a) $m(a_1-a_2)$ b) ma_2 c) ma_1 d) Data insufficient

10. A plumb bob is hung from the ceiling of a train compartment. The train moves on an inclined track of inclination 30° with horizontal. Acceleration of train up the plane is $a = g/2$. The angle which the string supporting the bob makes with normal to the ceiling in equilibrium is
a) 30° b) $\tan^{-1}(2/\sqrt{3})$ c) $\tan^{-1}(\sqrt{3}/2)$ d) $\tan^{-1}(2)$

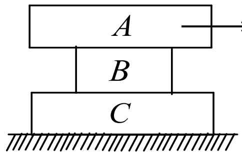
11. A coin is placed at the edge of a horizontal disc rotating about a vertical axis through its axis with a uniform angular speed 2 rad s^{-1} .The radius of the disc is 50 cm. Find the minimum coefficient of friction between disc and coin so that the coin does not slip ($g = 10\ ms^{-2}$)
a) 0.1 b) 0.2 c) 0.3 d) 0.4

12. The system shown in the figure is released from rest. The spring gets elongated



(Neglect friction and masses of pulley, string, and spring)
a) If $M > m$ b) If $M > 2m$ c) If $M > m/2$ d) For any value of M

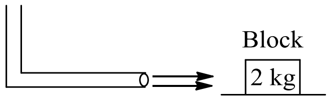
13. Find the least horizontal force P to start motion of any part of the system of the three blocks resting upon one another as shown in the figure. The weights of blocks are $A = 300$ N, $B = 100$ N, and $C = 200$ N. Between A and B, coefficients of friction is 0.3, between B and C is 0.2 and between C and the ground is 0.2



a) 60 N b) 90 N c) 80 N d) 70 N

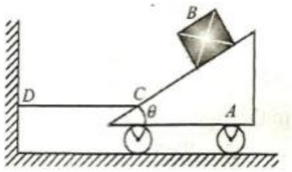
14. A man sits on a chair supported by a rope passing over a frictionless fixed pulley. The man who weights 1000 N exerts a force of 450 N on the chair downwards while pulling the rope on the other side. If the chair weights 250 N, then the acceleration of the chair is
a) 0.45 ms^{-2} b) Zero c) 2 ms^{-2} d) 9/25 ms^{-2}

15. A block of metal weighing 2 kg is resting on a frictionless plane. It is struck by a jet releasing water at a rate of 1 kgs^{-1} and at a speed of5 ms^{-1}. The initial acceleration of the block is



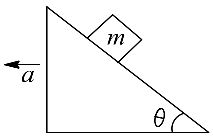
a) $\frac{5}{3}\mathrm{ms}^{-2}$ b) $\frac{25}{4}\mathrm{ms}^{-2}$ c) $\frac{25}{6}\mathrm{ms}^{-2}$ d) $\frac{5}{2}\mathrm{ms}^{-2}$

16. Block B has mass m and is released from rest when it is on top of wedge$A$, which has a mass$3m$. Determine the tension in cord CD needed to hold the wedge from moving while B is sliding down$A$. Neglect friction



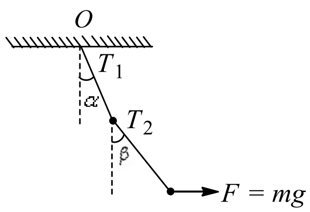
a) $2\,mg\cos\theta$ b) $\frac{mg}{2}\cos\theta$ c) $\frac{mg}{2}\sin\theta$ d) $mg\sin 2\theta$

17. A small block of mass m rests on a smooth wedge of angle θ. With what horizontal acceleration a should the wedge be pulled, as shown in the figure, so that the block falls freely?



a) $g\cos\theta$ b) $g\sin\theta$ c) $g\cot\theta$ d) $g\tan\theta$

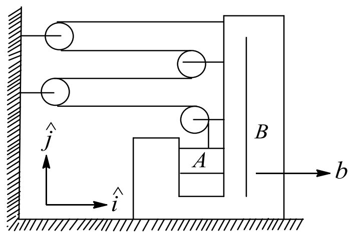
18. Two particles A and$B$, each of mass$m$, are kept stationary by applying a horizontal force $F = mg$ on particle B as shown in figure. Then



a) $2\tan\beta = \tan\alpha$ b) $2T_1 = 5T_2$ c) $T_1\sqrt{2} = T_2\sqrt{5}$ d) None of these

19. A suitcase is gently dropped on a conveyor belt moving at3 ms^{-1}. If the coefficient of friction between the belt and the suitcase is 0.5, find the displacement of the suitcase relative to conveyor belt before the slipping between the two is stopped: (g=10 ms^{-2})
a) 2.7 m b) 1.8 m c) 0.9 m d) 1.2 m

20. If block B moves towards right with acceleration b, find the net acceleration of block A



a) $b\hat{i} + 4b\hat{j}$ b) $b\hat{i} + b\hat{j}$ c) $b\hat{i} + 2b\hat{j}$ d) None of these

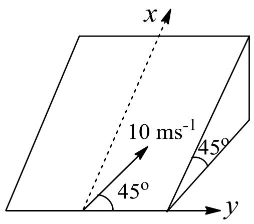
21. A particle is moving in the $x - y$ plane. At certain instant of time, the components of its velocity and acceleration are as follows $v_x = 3\ \text{ms}^{-1}, v_y = 4\ \text{ms}^{-1}, a_x = 2\ \text{ms}^{-2}$ and $a_y = 1\ \text{ms}^{-2}$. The rate of change of speed at this moment is

a) $\sqrt{10}\ \text{ms}^{-1}$ b) $4\ \text{ms}^{-2}$ c) $\sqrt{5}\ \text{ms}^{-2}$ d) $2\ \text{ms}^{-2}$

22. A particle moves in the X-Yplane under the influence of a force such that its linear momentum is $\mathbf{p}(t) = A[\hat{\mathbf{i}}\cos(kt) - \hat{\mathbf{j}}\sin(kt)]$ where A and k are constant. The angle between the force and the momentum is

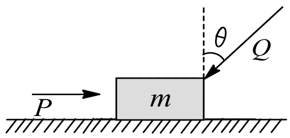
a) 0° b) 30° c) 45° d) 90°

23. The small marble is projected with a velocity of $10\ \text{ms}^{-1}$ in a direction 45° from the horizontal y-direction on the smooth inclined plane. Calculate the magnitude v of its velocity after 2 s



a) $10\sqrt{2}\ \text{ms}^{-1}$ b) $5\ \text{ms}^{-1}$ c) $10\ \text{ms}^{-1}$ d) $5\sqrt{2}\ \text{ms}^{-1}$

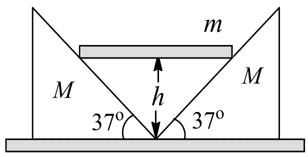
24. A block of mass$m$, lying on a horizontal plane, is acted upon by a horizontal force P and another force$Q$, inclined at an angle θ to the vertical. The block will remain in equilibrium if the coefficient of friction between it and the surface is (assume $P > Q$)



a) $(P\sin\theta - Q)/(mg - \cos\theta)$ b) $(P - Q\sin\theta)/(mg + Q\cos\theta)$

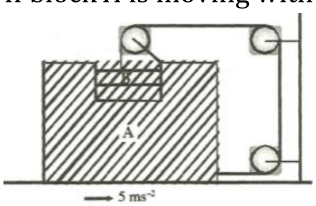
c) $(P\cos\theta + Q)/(mg - Q\cos\theta)$ d) $(P + Q\sin\theta)/(mg + Q\cos\theta)$

25. A body of mass m is held at rest at a height h on two smooth wedges of mass M each, which are themselves at rest on a horizontal frictionless surface. When the mass m is released, it moves down, pushing aside the wedges. The velocity with which the wedge recede from each other, when m reaches the ground, is



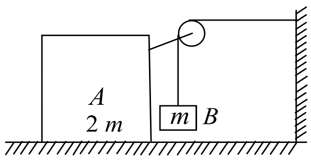
a) $\sqrt{\dfrac{8mgh}{m + 2M}}$ b) $\sqrt{\dfrac{40mgh \times 4}{5m + 6M}}$ c) $\sqrt{\dfrac{32mgh \times 4}{32M + 9m}}$ d) None of these

26. If block A is moving with an acceleration of $5\ \text{ms}^{-2}$, the acceleration of B w.r.t. ground is



a) $5\ \text{ms}^{-2}$ b) $5\sqrt{2}\ \text{ms}^{-2}$ c) $5\sqrt{5}\ \text{ms}^{-2}$ d) $10\ \text{ms}^{-2}$

27. In the system shown all the surfaces are frictionless while pulley and string are massless. Mass of block A is $2\ m$ and that of block B is m. Acceleration of block B immediately after system is released from rest is



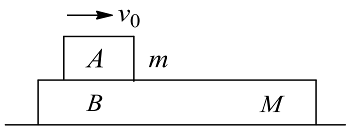
a) g/2 b) G c) g/3 d) None of these

28. A horizontal force, just sufficient to move a body of mass 4 kg lying on a rough horizontal surface, is

applied on it. The coefficient of static and kinetic friction between the body and the surface are 0.8 and 0.6, respectively. If the force continuous to act even after the block has started moving, the acceleration of the block in ms^{-2} is (g=10 ms^{-2})

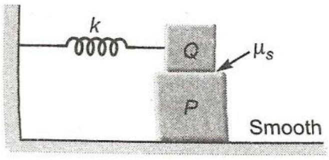
a) 1/4 b) 1/2 c) 2 d) 4

29. The masses of the blocks A and B are m and$M$, respectively. Between A and B there is constant frictional force$F$, and B can slide frictionlessly on horizontal surface. A is set in motion with velocity while B is at rest. What is the distance moved by A relative to B before they move with the same velocity?



a) $\frac{mMv_0^2}{F(m-M)}$ b) $\frac{mMv_0^2}{2F(m-M)}$ c) $\frac{mMv_0^2}{F(m+M)}$ d) $\frac{mMv_0^2}{2F(m+M)}$

30. A block P of mass m is placed on a horizontal surface. Another block Q of same mass is kept on P and connected to the wall with the help of a spring of spring constant k as shown in the figure. μ_s is the coefficient of friction between P and Q. The blocks move together performing SHM of amplitude A. The maximum value of the friction force between P and Q is



a) kA b) $\frac{kA}{2}$ c) Zero d) $\mu_s\, mg$

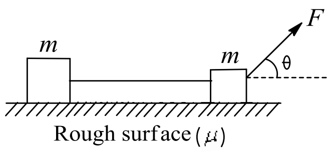
31. Consider a 14-tyre truck, whose only rear 8 wheels are power driven (means only these 8 wheels can produce acceleration). These 8 wheels are supporting approximately half of the entire load. If coefficient of friction between rod and each of the tyres is 0.6, then what could be the maximum attainable acceleration by this truck?

a) 6 ms^{-2} b) 24 ms^{-2} c) 3 ms^{-2} d) 10 ms^{-2}

32. A block of metal weighing 2 kg is resting on a frictionless plane. It is struck by a jet releasing water at a rate of 1 kgs^{-1} and a speed of5 ms^{-1}. The initial acceleration of the block will be

a) 2.5 ms^{-2} b) 5 ms^{-2} c) 10 ms^{-2} d) 20 ms^{-2}

33. Two blocks m and M tied together with an inextensible string are placed at rest on a rough horizontal surface with coefficient of frictionμ. The block m is pulled with a variable force F at a varying angle θ with the horizontal. The value of θ at which the least value of F is required to move the blocks is given by



a) $\theta = \tan^{-1}\mu$ b) $\theta > \tan^{-1}\mu$ c) $\theta < \tan^{-1}\mu$ d) Insufficient data

34. A circular table of radius 0.5 m has smooth diametrical groove. A ball of mass 90 g is placed inside the groove along with a spring of spring constant10^2 Ncm^{-1}. One end of the spring is tied to the edge of the table and the other end to the ball. The ball is at a distance of 0.1 m from the centre when the table is at rest. On rotating the table with a constant angular frequency of 10^2 rad s^{-1}, the ball moves away from the centre by a distance nearly equal to

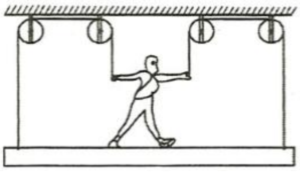
a) 10^{-1}m b) 10^{-2}m c) 10^{-3}m d) 2×10^1 m

35. A small block slides without friction down an inclined plane starting from rest. Let s_n be the distance travelled from time $t = n - 1$ to $t = n$. Then

$\frac{s_n}{s_n + 1}$ is

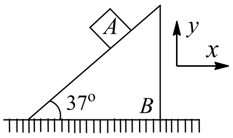
a) $\frac{2n-1}{2n}$ b) $\frac{2n+1}{2n-1}$ c) $\frac{2n-1}{2n+1}$ d) $\frac{2n}{2n+1}$

36. A painter of mass M stands on a platform of mass m and pulls himself up by ropes which hang over pulley as shown. He pulls each rope with force F and moves upward with a uniform acceleration$a$. Find a, neglecting the fact that no one could do this for long time



a) $\frac{4F+(2M+m)g}{M+2m}$ b) $\frac{4F+(M+m)g}{M+2m}$ c) $\frac{4F-(M+m)g}{M+m}$ d) $\frac{4F-(M+m)g}{2M+m}$

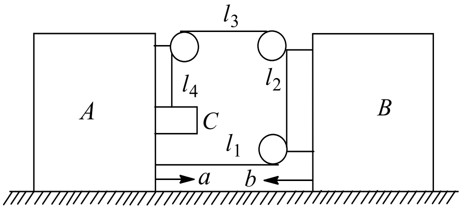
37. In the figure shown, the acceleration of A is $\vec{a}_A = 15\hat{\imath} + 15\hat{\jmath}$, then the acceleration of B is (A remains in contact with B)



a) $6\hat{\imath}$ b) $-15\hat{\imath}$ c) $-10\hat{\imath}$ d) $-5\hat{\imath}$

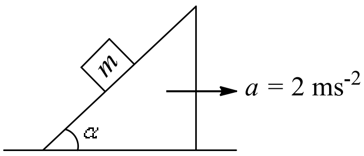
38. An object moving with a constant acceleration in a non-inertial frame
a) Must have non-zero net force acting on it
b) May have zero net force acting on it
c) May have no force acting on it
d) This situation is practically impossible. (The pseudo force acting on the object has also to be considered)

39. If the blocks A and B are moving towards each other with acceleration a and b as shown in the figure, find the net acceleration of block C



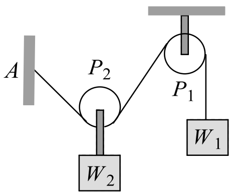
a) $a\hat{\imath} - 2(a+b)\hat{\jmath}$ b) $-(a+b)\hat{\jmath}$ c) $a\hat{\imath} - (a+b)\hat{\jmath}$ d) None of these

40. A block of mass m is lying on a wedge having inclination angle$\alpha = \tan^{-1}\left(\frac{1}{5}\right)$. Wedge is moving with a constant acceleration $a = 2\ \mathrm{ms}^{-2}$. The minimum value of coefficient of friction μ so that m remains stationary w.r.t. wedge is



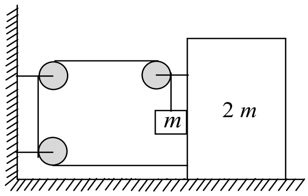
a) 2/9 b) 5/12 c) 1/5 d) 2/5

41. In the following figure, the pulley P_1 is fixed and the pulley P_2 is movable. If $W_1 = W_2 = 100$ N, what is the angleAP_2P_1? The pulleys are frictionless and assume equilibrium



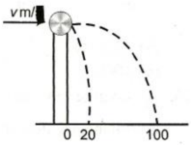
a) 30° b) 60° c) 90° d) 120°

42. In the system shown in the figure, the friction coefficient between ground and bigger block isμ. 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



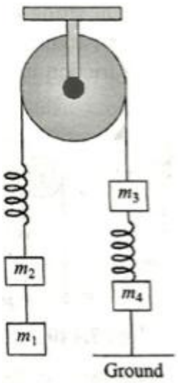
a) $\frac{1}{2}$ b) $\frac{1}{3}$ c) $\frac{2}{3}$ d) $\frac{3}{2}$

43. A ball of mass 0.2 kg rests on a vertical post of height 5 m. A bullet of mass 0.01 kg, travelling with a velocity v m/s in a horizontal direction, hits the centre of the ball. After the collision, the ball and bullet travel independently. The ball hits the ground at a distance of 20 m and the bullet at ball hits the ground at a distance of 100 m from the foot of the post. The initial velocity v of the bullet is



a) 250 m/s b) $250\sqrt{2}$ m/s c) 400 m/s d) 500 m/s

44. For the system shown in the figure, $m_1 > m_2 > m_3 > m_4$. Initially, the system is at rest in equilibrium condition. If the string joining m_4 and ground is cut, then just after the string is cut



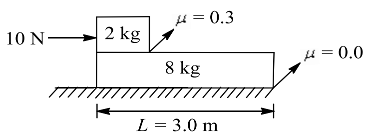
Statement I: m_1, m_{23}, m_3 remain stationary
Statement II: the value of acceleration of all the four blocks can be determined
Statement III: Only m_4 remains stationary
Statement IV: Only m_4 accelerates
Now, choose the correct options

a) All the statements are correct b) Only I, II and IV are correct
c) Only I and II are correct d) Only II and IV are correct

45. A block of base 10 cm × 10 cm and height 15 cm is kept on an inclined plane. The coefficient of friction between them is $\sqrt{3}$. The inclination θ of this inclined plane from the horizontal plane is gradually increased from 0°. Then,

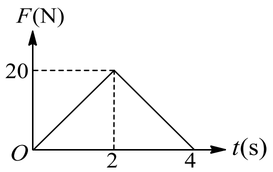
a) at 0 = 30°, the block will start sliding down the plane
b) The block will remain at the rest on the plane up to certain θ and then it will topple
c) At θ = 60°, the block will start sliding down the plane and continue to do so at higher angles
d) At θ = 60°, the block will start sliding down the plane and on further increasing θ, it will topple at certain θ

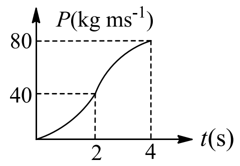
46. Determine the time in which the smaller block reaches other end of bigger block in the figure

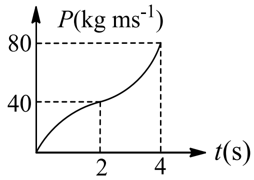


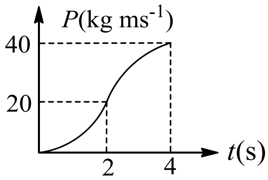
a) 4 s b) 8 s c) 2.19 s d) 2.13 s

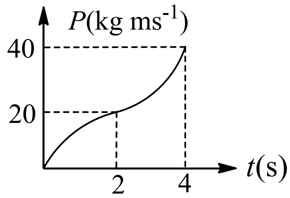
47. Figure shows the variation of force acting on a body with time. Assuming the body to start from rest, the variation of its momentum with time is best represented by which plot?



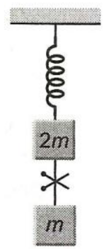
a) 

b) 

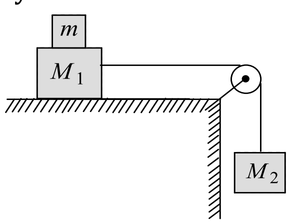
c) 

d) 

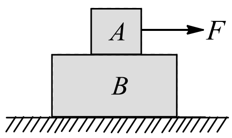
48. A circular road of radius 1000 m has banking angle45°. The maximum safe speed (in ms^{-1}) of a car having a mass 2000 kg will be, if the coefficient of friction between type and road is 0.5
   a) 172 b) 124 c) 99 d) 86
49. System shown in figure is in equilibrium and at rest. The spring and string are massless, now the string is cut. The acceleration of mass 2 m and m just after the string is cut will be



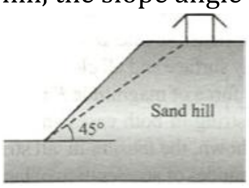
   a) $g/2$ upward, g downward
   b) g upward, $g/2$ downward
   c) g upward, $2g$ downward
   d) $2g$ upward, g downward
50. Two blocks of masses M_1 and M_2 are connected with a string passing over a pulley as shown in figure. The block M_1 lies on a horizontal surface. The coefficient of friction between the block M_1 and the horizontal surface isμ. The system accelerates. What additional mass m should be placed on the block M_1 so that the system does not accelerate?



   a) $\dfrac{M_2 - M_1}{\mu}$ b) $\dfrac{M_2}{\mu} - M_1$ c) $M_2 - \dfrac{M_1}{\mu}$ d) $(M_2 - M_1)\mu$
51. A block A of mass 2 kg is placed over another block B of mass 4 kg, which is placed over a smooth horizontal floor. The coefficient of friction between A and B is 0.4. when a horizontal force of magnitude 10 N is applied on A, the acceleration of blocks A and B are



   a) $1\ \mathrm{ms}^{-2}$ and $2\ \mathrm{ms}^{-2}$, respectively
   b) $5\ \mathrm{ms}^{-2}$ and $2.5\ \mathrm{ms}^{-2}$, respectively
   c) Both the blocks will moves together with acceleration $1/3\ \mathrm{ms}^{-2}$
   d) Both the blocks will move together with acceleration, $5/3\ \mathrm{ms}^{-2}$
52. A house is built on the top of a hill with 45° slope. Due to sliding of material and sand from top to bottom of hill, the slope angle has been reduced



   If coefficient of static friction between sand particles is 0.75, what is the final angle attained by hill?

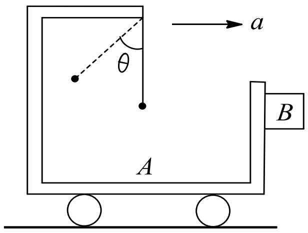
$(\tan^{-1} 0.75 \backsimeq 37°)$

a) $8°$ b) $45°$ c) $37°$ d) $30°$

53. A balloon of mass M is descending at a constant acceleration α. When a mass m is released from the balloon, it starts rising with the same acceleration α. Assuming that its volume does not change, what is the value of m?

a) $\frac{\alpha}{\alpha + g}M$ b) $\frac{2\alpha}{\alpha + g}M$ c) $\frac{\alpha + g}{\alpha}M$ d) $\frac{\alpha + g}{2\alpha}M$

54. A trolley A has a simple pendulum suspended from a frame fixed to its desk. A block B is in contact on its vertical slide. The trolley is on horizontal rails and accelerates towards the right such that the block is just prevented from falling. The value of coefficient of friction between A and B is 0.5. The inclination of the pendulum to the vertical is

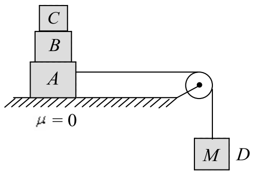


a) $\tan^{-1}\left(\frac{1}{2}\right)$ b) $\tan^{-1}(3)$ c) $\tan^{-1}(\sqrt{2})$ d) $\tan^{-1}(2)$

55. A block of mass M is pulled along a horizontal frictionless surface by a rope of mass m. Force P is applied at one end of rope. The force which the rope exerts on the block is

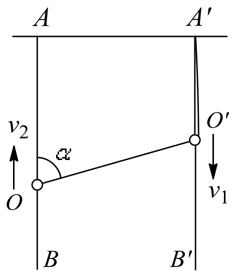
a) $\frac{P}{(M - m)}$ b) $\frac{P}{M(m + M)}$ c) $\frac{PM}{(m + M)}$ d) $\frac{PM}{(M - m)}$

56. Three blocks A, B and C of equal mass m are placed one over the other on a frictionless surface (table) as shown in the figure. Coefficient of friction between any blocks A, B and C is μ. The maximum value of mass of block D so that the blocks A, B and C move without slipping over each other is



a) $\frac{3m\mu}{\mu + 1}$ b) $\frac{3m(1 - \mu)}{\mu}$ c) $\frac{3m(1 + \mu)}{\mu}$ d) $\frac{3m\mu}{(1 - \mu)}$

57. Two small rings O and O' are put two vertical stationary rods AB and $A'B'$, respectively. One end of an inextensible thread is tied at point A'. The thread passes through ring O' and its other end is tied to ring O. Assuming that ring O' moves downwards at a constant at a constant velocity v_1, then velocity v_2 of the ring O, when $\angle AOO' = \alpha$, is



a) $v_1\left[\frac{2\sin^2 \alpha/2}{\cos \alpha}\right]$ b) $v_1\left[\frac{2\cos^2 \alpha/2}{\sin \alpha}\right]$ c) $v_1\left[\frac{3\cos^2 \alpha/2}{\sin \alpha}\right]$ d) None of these

58. **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.

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

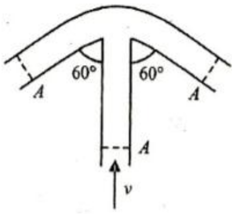
a) Statement I is true, statement II is true; statement II is a correct explanation for statement I

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

59. An ideal liquid of density ρ is pushed with velocity v through the central limb of the tube shown in the figure. What force does the liquid exert on the tube? The cross sectional areas of the three limbs are equal to A each. Assume stream-line flow



a) $\frac{9}{8}\rho Av^2$ b) $\frac{5}{4}\rho Av^2$ c) $\frac{3}{2}\rho Av^2$ d) ρAv^2

60. A professor holds an eraser against a vertical chalkboard by pushing horizontally on it. He pushes with a force that is much greater than it required to hold the eraser. The force friction exerted by the board on the eraser increases if he

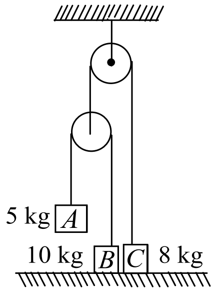
a) Pushes eraser with slightly greater force

b) Pushes eraser with slightly less force

c) Raiser his elbow so that the force he exerts is lightly downward but has same magnitude

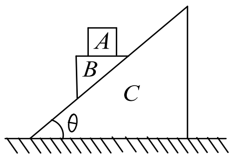
d) Lowers his elbow so that the force he exerts is slightly upward but the same magnitude

61. 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 block C will be



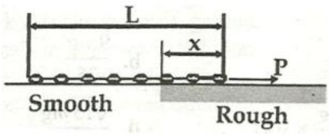
a) Zero b) 2.5 ms^{-2} c) 10/7 ms^{-2} d) 5/7 ms^{-2}

62. In the figure shown, all blocks are of equal mass$m$. All surfaces are smooth. The acceleration of the block A with respect ground is



a) $\frac{4g\sin\theta}{1+3\sin^2\theta}$ b) $\frac{4g\sin^2\theta}{1+3\sin^2\theta}$ c) $\frac{4g\sin^2\theta}{\sqrt{1+3\sin^2\theta}}$ d) None of these

63. A chain of length L is placed on a horizontal surface as shown in the 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 figure). In the duration x chnages from $x = 0$ to$x = L$. For chain to move with constant speed,



a) The magnitude of P should increase with time

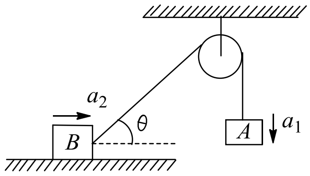
b) The magnitude of P should decrease with time

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

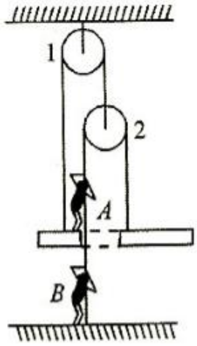
64. Figure shows two blocks, each of mass$m$. The system is released from rest. If acceleration of blocks A and

Bat any instant (not initially) are a_1 and a_2, respectively, then



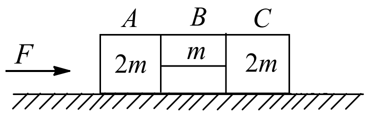
a) $a_1 = a_2 \cos\theta$ b) $a_2 = a_1 \cos\theta$ c) $a_1 = a_2$ d) None of these

65. In the given diagram, man A is standing on a movable plank while man B is standing on a stationary platform. Both are pulling the string down such that the plank moves slowly up. As a result of this the string slips through the hands of the men. Find the ratio of length of the string that slips through the hands of A and B



a) 3/2 b) 3/4 c) 4/3 d) 2/3

66. A system is pushed by a force Fas shown in figure. All surfaces are smooth except between B and$C$. Friction coefficient between B and C isμ. Minimum value of F to prevent block B from down ward slipping is

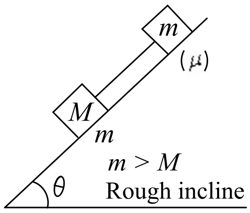


a) $\left(\frac{3}{2\mu}\right) mg$ b) $\left(\frac{5}{2\mu}\right) mg$ c) $\left(\frac{5}{2}\right) \mu mg$ d) $\left(\frac{3}{2}\right) \mu mg$

67. A body of mass m is launched up on a rough inclined plane making an angle 45° with horizontal. If the time of ascent is half of the time of descent, the friction coefficient between plane and body is

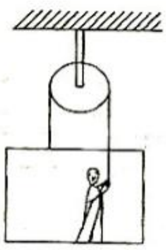
a) $\frac{2}{5}$ b) $\frac{3}{5}$ c) $\frac{3}{4}$ d) $\frac{4}{5}$

68. In figure, the tension in the rope (rope is light) is



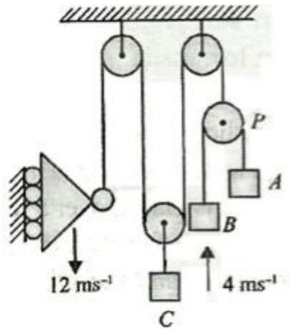
a) $(M + m)g \sin\theta$ b) $(M + m)g \sin\theta - \mu\, mg \cos\theta$
c) Zero d) $(M + m)g \cos\theta$

69. A person is drawing himself up and a trolley on which he stands with some acceleration. Mass of the person is more than the mass of the trolley. As the person increases his force on the string, the normal reaction between person and the trolley will



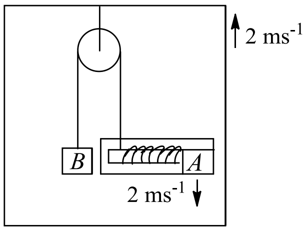
a) Increase
b) Decrease
c) Remain same
d) Cannot be predicted s data is insufficient

70. In the arrangement shown in the figure below at a particular instant the roller is coming down with a speed of 12 ms^{-1} and C is moving up with 4 ms^{-1}. At the same instant, it is also known that w.r.t pulley P, block A is moving down with speed 3 ms^{-1}. Determine the motion of block B (velocity) w.r.t. ground



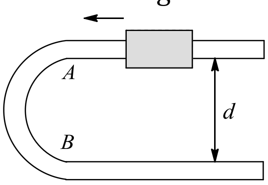
a) 4 ms^{-1} in downward direction
b) 3 ms^{-1} in upward direction
c) 7 ms^{-1} in downward direction
d) 7 ms^{-1} in upward direction

71. In the figure shown the velocity of lift is 2 ms^{-1} while string is winding on the motor shaft with velocity 2 ms^{-1} and block A is moving downwards with velocity of 2 ms^{-1}, then find out the velocity of block B



a) 2 ms^{-1} ↑
b) 2 ms^{-1} ↑
c) 4 ms^{-1} ↑
d) None of these

72. A fixed U-shaped smooth wire has a semi-circular bending between A and B as shown in figure. A bead of mass m moving with uniform speed v through the wire enters the semiconductor bend at A and leaves at B. The averages force exerted by the bead on the part AB of the wire is

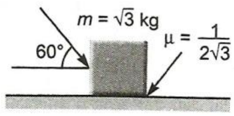


a) 0
b) $\dfrac{4mv^2}{\pi d}$
c) $\dfrac{2mv^2}{\pi d}$
d) None of these

73. A block is lying on the horizontal frictionless surface. One end of a uniform rope is fixed to the block which is pulled in the horizontal direction by applying a force F at the other end. If the mass of the rope is half the mass of the block, the tension in the middle of the rope will be

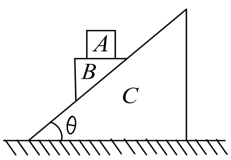
a) F
b) $2\,F/3$
c) $3\,F/5$
d) $5\,F/6$

74. What is the maximum value of the force F such that the block shown in the arrangement, does not move?



a) 20 N
b) 10 N
c) 12 N
d) 15 N

75. In the figure shown, all blocks are of equal mass$m$. All surfaces are smooth, the acceleration of C w.r.t. ground is

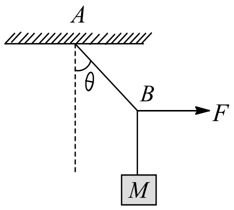


a) $\dfrac{2g\sin\theta\cos\theta}{1+3\sin^2\theta}$
b) $\dfrac{g\sin\theta\cos\theta}{1+3\sin^2\theta}$
c) $\dfrac{g\sin 2\theta}{\sqrt{1+3\sin^2\theta}}$
d) $\frac{g\sin\theta\cos\theta}{\sqrt{1+3\sin^2\theta}}+$

76. A box of mass 8 kg is placed on a rough inclined plane of inclinationθ. Its downwards motion can be prevented by applying an upward pull F and it can be made to slide upwards by applying an upward pull F and it can be made to slide upwards by applying a force2 F. The coefficient of friction between the box and the inclined plane is

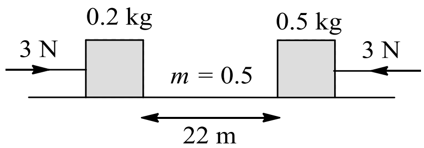
a) $(\tan\theta)/3$ b) $3\tan\theta$ c) $(\tan\theta)/2$ d) $2\tan\theta$

77. A mass M is suspended by a rope from a rigid support at A as shown in figure. Another rope is tied at the end B and it is pulled horizontally with a force$F$. If the rope AB makes an angle θ with the vertical, then the tension in the string AB is



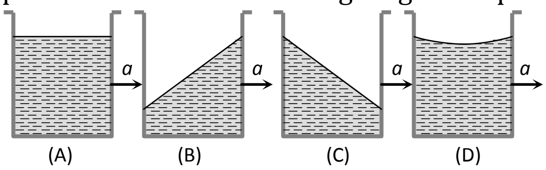
a) $F\sin\theta$ b) $F/\sin\theta$ c) $F\cos\theta$ d) $F/\cos\theta$

78. Two blocks of masses 0.2 kg and 0.5 kg, which are placed 22 m apart on a rough horizontal surface ($\mu = 0.5$), are acted upon by two forces of magnitude 3 N each as shown in figure at time $t = 0$. Then, the time t at which they collide with each other is



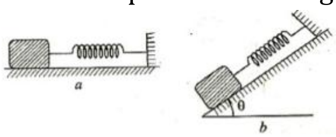
a) 1 s b) $\sqrt{2}$ s c) 2 s d) None

79. A vessel containing water is given a constant acceleration a towards the right, along a straight horizontal path. Which of the following diagram represents the surface of the liquid

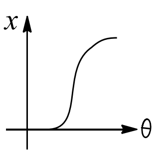


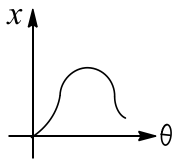
a) A b) B c) C d) D

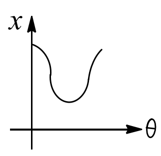
80. A block is placed on a rough horizontal plane attached with an elastic spring as shown in the figure

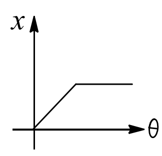


Initially spring is unstretched. If the plane is gradually lifted from $\theta = 0° \; to \; \theta = 90°$, then the graph showing extension in the spring (x) versus angle (θ) is

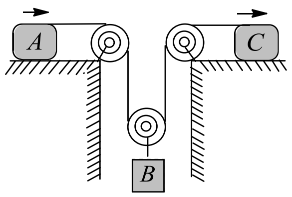
a) 

b) 

c) 

d) 

81. Blocks A and C stat from rest and move to the right with acceleration $a_A = 12\,t\,ms^{-2}$ and$a_c = 3\,ms^{-2}$. Here t is in seconds. The time when block B again comes to rest is



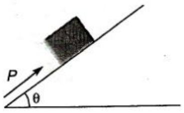
a) 2 s b) 1 s c) 3/2 s d) 1/2 s

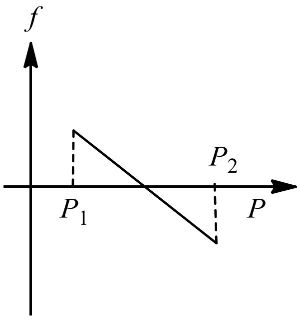
82. A passenger is travelling a train moving at40 ms^{-1}. His suitcase is kept on the berth. The driver of train applies breaks such that the speed of the train decreases at a constant rate to 20 ms^{-1} in 5 s. What should

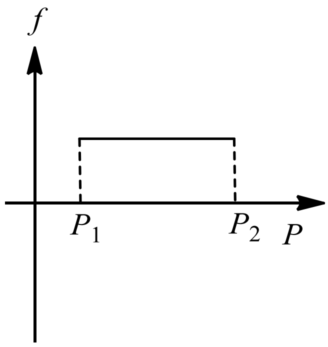
be the minimum coefficient of friction between the suitcase and the berth if the suitcase is not to slide during retardation of the train?

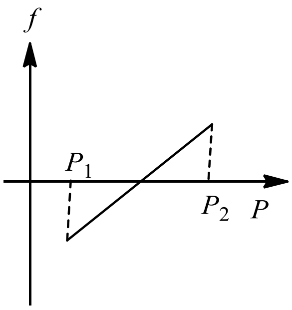
a) 0.3 b) 0.5 c) 0.1 d) 0.2

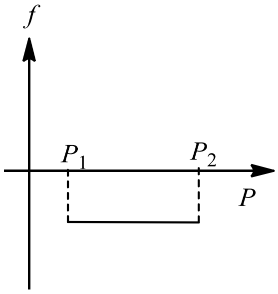
83. A block of mass m is on an inclined plane of angle θ. The coefficient of friction between the block and the plane is μ and $\tan\theta > \mu$. The block is held stationary by applying a force E parallel to the plane. The direction of force pointing up the plane is taken to be positive. As P is varied 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



a)


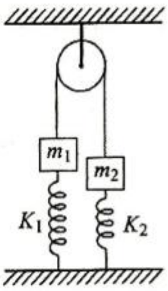
b)


c)


d)


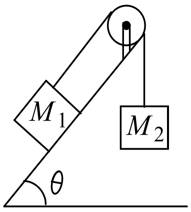
84. Which of the following is correct, when a person walks on a rough surface
a) The frictional force exerted by the surface keeps him moving
b) The force which the man exerts on the floor keeps him moving
c) The reaction of the force which the man exerts on floor keeps him moving
d) None of the above

85. The system shown in figure is in equilibrium. Masses m_1 and m_2 are 2 kg and 8 kg, respectively. Spring constants k_1 and k_2 are 50 $\mathrm{Nm^{-1}}$ and70 $\mathrm{Nm^{-1}}$, respectively. If the compression in second spring is 0.5 m. What is the compression in first spring? (Both springs have natural length initially)



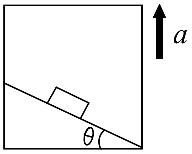
a) 1.3 m b) −0.5 m c) 0.5 m d) 0.9 m

86. Two blocks of masses M_1 and M_2 are connected with a string which passes over a smooth pulley. The mass M_1 is placed on a rough incline plane as shown in the figure. The coefficient of friction between the block and the inclined plane isμ. What should be the minimum mass M_2 so that the block M_1 slides upwards?



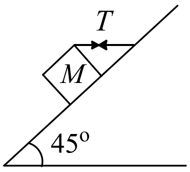
a) $M_2 = M_1(\sin\theta + \mu\cos\theta)$
b) $M_2 = M_1(\sin\theta + \mu\cos\theta)$
c) $M_2 = \dfrac{M_1}{\sin\theta + \mu\cos\theta}$
d) $M_2 = \dfrac{M_1}{\sin\theta - \mu\cos\theta}$

87. A block of mass m is at rest with respect to a rough incline kept in elevator moving up with acceleration$a$. Which of following statements is correct?



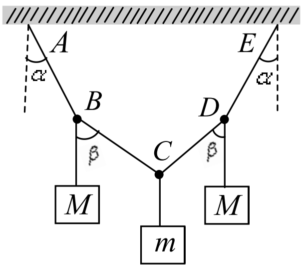
a) The contact force between block and incline is parallel to the incline
b) The contact force between block and incline is of the magnitude $m(\mathrm{g} + a)$
c) The contact force between block and incline is perpendicular to the incline
d) The contact force is of magnitude $mg\cos\theta$

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



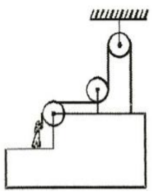
a) 1/2
b) 2/3
c) 3/4
d) 1/4

89. The figure represents a light inextensible string $ABCDE$ in which $AB = BC = CD = DE$ and to which are attached masses M, m and M at the points B, C and$D$, respectively. The system hangs freely in equilibrium with ends A and E of the string fixed in the same horizontal line. It is given that $\tan\alpha = 3/4$ and$\tan\beta = 12/5$. Then the tension in the string BC is



a) 2 mg
b) $(13/10)mg$
c) $(3/10)mg$
d) $(20/11)mg$

90. A system is shown in the figure. A man standing on the block is pulling the rope. String slips through the hands of man with velocity 2 ms^{-1} w.r.t. man. The velocity of the block will be (assume that the block does not rotate)

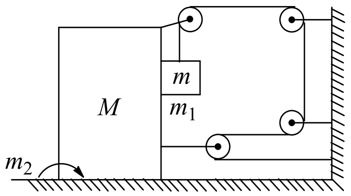


a) 3 ms^{-1}
b) 2 ms^{-1}
c) 1/2 ms^{-1}
d) 1 ms^{-1}

91. A block of mass 0.1 kg is held against a wall by applying a horizontal force of 5 N 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

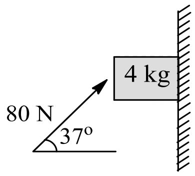
a) 2.5 N
b) 0.98 N
c) 4.9 N
d) 0.49 N

92. Two blocks M and m are arranged as shown in the diagram. The coefficient of friction between the blocks is $\mu_1 = 0.25$ and between the ground and M is $\mu_2 = \frac{1}{3}$. If $M = 8$ kg, then find the value of m so that the system will remain at rest



a) 4/3 kg b) 8/9 kg c) 1 kg d) 8/5 kg

93. A block of mass 4 kg is pressed against the wall by a force of 80 N as shown in the figure. Determine the value of friction force and block's acceleration (take $\mu_s = 0.2, \mu_k = 0.15$)



a) 8 N, 0 ms^{-2} b) 32 N, 6 ms^{-2} c) 8 N, 6 ms^{-2} d) 32 N, 2 ms^{-2}

94. A rope of length 4 m having mass 1.5 kg per metre lying on a horizontal friction less surface is pulled at one end by a force of 12 N. What is the tension in the rope at a point 1.6 m from the other end?

a) 5 N b) 4.8 N c) 7.2 N d) 6 N

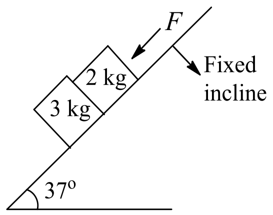
95. A particle of mass 2 kg moves with an initial velocity of $\vec{v} = 4\hat{\imath} + 4\hat{\jmath} \text{ ms}^{-1}$. A constant force of $\vec{F} = -20\hat{\jmath}$ N is applied on the particle. Initially, the particle was at (0, 0). The x-coordinate of the particle when its y-coordinates again becomes zero is given by

a) 1.2 m b) 4.8 m c) 6.0 m d) 3.2 m

96. A body of mass M is resting on a rough horizontal plane surface, the coefficient of friction being equal to μ. At $t = 0$, a horizontal force $F = F_0 t$ starts acting on it, where F_0 is a constant. Find the time T at which the motion starts?

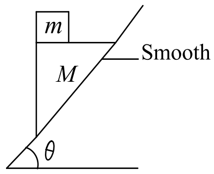
a) $\mu Mg/F_0$ b) $Mg/\mu F_0$ c) $\mu F_0/Mg$ d) None of these

97. Two blocks of masses 3 kg and 2 kg are placed side by side on an incline as shown in the figure. A force $F = 20$ N is acting on 2 kg block along the incline. The coefficient of friction between the block and the incline is same and equal to 0.1. find the normal contact force exerted by 2 kg block on 3 kg block



a) 18 N b) 30 N c) 12 N d) 27.6 N

98. A triangular prism of mass M with a block of mass m placed on it is released from rest on a smooth inclined plane of inclination θ. The block does not slip on the prism. Then



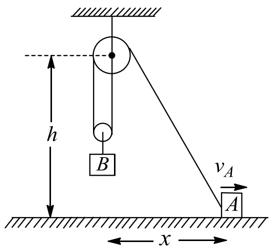
a) The acceleration of the prism is g $\cos\theta$

b) The acceleration of the prism is g $\tan\theta$

c) The minimum coefficient of friction between the block and the prism is $\mu_{\min} = \cot\theta$

d) The minimum coefficient of friction between the block and the prism is $\mu_{\min} = \tan\theta$

99. If block A is moving horizontally with velocity v_A, then find the velocity of block B at the instant as shown in the figure



a) $\frac{hv_A}{2\sqrt{x^2+h^2}}$
b) $\frac{xv_A}{\sqrt{x^2+h^2}}$
c) $\frac{xv_A}{2\sqrt{x^2+h^2}}$
d) $\frac{hv_A}{\sqrt{x^2+h^2}}$

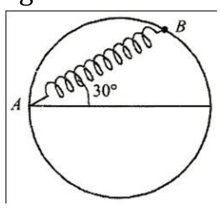
100. Three forces are acting on a particle of mass m initially in equilibrium. If the first two forces (R_1 and R_2) are perpendicular to each other and suddenly the third force (R_3) is removed, then the acceleration of the particle is

a) $\frac{R_3}{m}$
b) $\frac{R_1+R_2}{m}$
c) $\frac{R_1-R_2}{m}$
d) $\frac{R_1}{m}$

101. A block of base 10 $cm \times 10$ cm and height 15 cm is kept on an inclined plane. The coefficient of friction between them is $\sqrt{3}$. The inclination θ of this inclined plane from the horizontal plane is gradually increased from 0°. Then

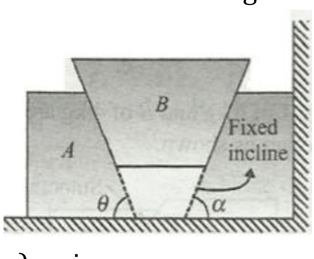
a) At $\theta = 30°$, the block will start sliding down the plane
b) The block will remain at rest on the plane up to certain θ and then it will topple
c) At $\theta = 60°$, the block will start sliding down the plane and continue to do so at higher angles
d) At $\theta = 60°$, the block will start sliding down the plane and on further increasing θ, it will topple at certain θ

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



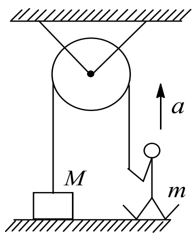
a) $mg/2$
b) $\sqrt{3}\,mg$
c) $3\sqrt{3}\,mg$
d) $\frac{3\sqrt{3}\,mg}{2}$

103. In the shown arrangement below, if acceleration of B is $\vec{a}$, then find the acceleration of A



a) $a\sin\alpha$
b) $a\cot\theta$
c) $a\tan\theta$
d) $(\sin\alpha\cot\theta + \cos\alpha)$

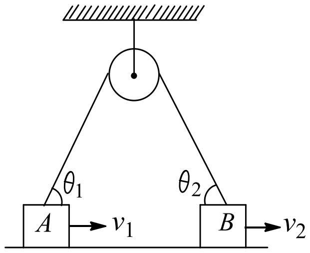
104. In the figure, the block of mass M is at rest on the floor. The acceleration with which a boy of mass m should climb along the rope of negligible mass so as to lift the block from the floor is



a) $\left(\frac{M}{m}-1\right)$ g
b) $\left(\frac{M}{m}-1\right)$ g
c) $\frac{M}{m}$ g
d) $> \frac{M}{m}$ g

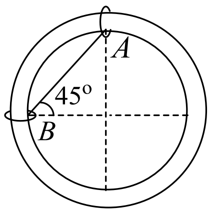
105. In the figure shown, blocks A and B move with velocities v_1 and v_2 along horizontal direction. Find the

ratio of v_1/v_2

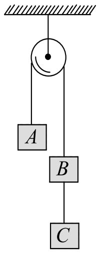


a) $\frac{\sin\theta_1}{\sin\theta_2}$ b) $\frac{\sin\theta_2}{\sin\theta_1}$ c) $\frac{\cos\theta_2}{\cos\theta_1}$ d) $\frac{\cos\theta_1}{\cos\theta_2}$

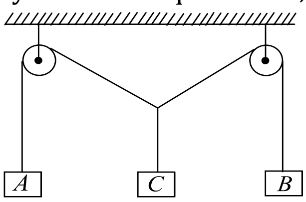
106. An object moving with constant velocity in a non-inertial; frame of reference
   a) Must have non-zero net force acting on it
   b) May have zero net force acting on it
   c) Must have zero net force acting on it
   d) May have non-zero net force acting on it (Consider only the real forces)
107. A heavy uniform chain lies on a horizontal table top. If the coefficient of friction between the chain and the table surface is 0.25, then the maximum fraction of the length of the chain that can hang over one edge of the table is
   a) 20 % b) 25 % c) 35 % d) 15 %
108. Two objects A and$B$, each of mass$m$, are connected by a light inextensible string. They are restricted to move on a frictionless ring of radius R in a vertical plane (as shown in the figure). The objects are released from rest at the position shown. Then the tension in the cord just after release is



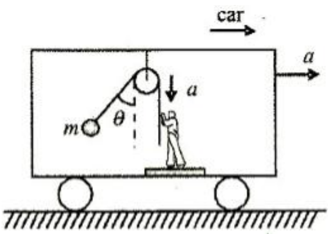
   a) Zero b) mg c) $\sqrt{2}\,mg$ d) $mg/\sqrt{2}$
109. Three equal weights A, B, C of mass 2 kg each are hanging on a string passing over a fixed frictionless pulley as shown in the figure. The tension in the string connecting weights B and C is



   a) Zero b) 13 N c) 3.3 N d) 19.6 N
110. Three blocks A, B and C are suspended as shown in the figure. Mass of each of blocks A and B is$m$. If system is in equilibrium, and mass of C is M, then

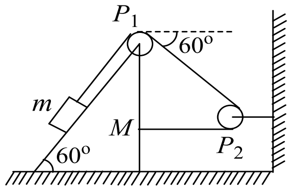


   a) $M > 2\,m$ b) $M = 2\,m$ c) $M < 2\,m$ d) None of these
111. A bob is hanging over a pulley inside a car through a string. The second end of the string is in the hands of a person standing in the car. The car is moving with constant acceleration a directed horizontally as shown in the figure. Other end of the string is pulled with constant acceleration a vertically. 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) $m(g+a)$

112. In the arrangement shown in the figure, the block of mass $m=2kg$ lies on the wedge of mass $M=8$ kg. the initial acceleration of the wedge, if the surfaces are smooth, is

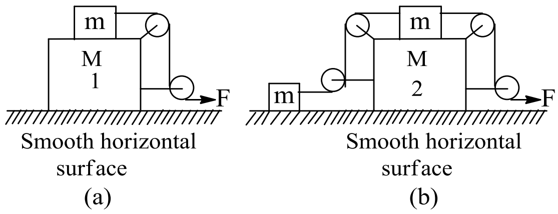


a) $\frac{\sqrt{3}g}{23}$ ms^{-2} b) $\frac{3\sqrt{3}g}{23}$ ms^{-2} c) $\frac{3g}{23}$ ms^{-2} d) $\frac{g}{23}$ ms^{-2}

113. A given object takes n times more time to slide down 45° rough inclined plane as it takes to slide down a perfectly smooth 45° incline. The coefficient of kinetic friction between the object and the incline is

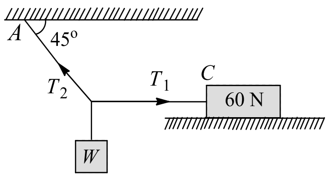
a) $\sqrt{\frac{1}{1-n^2}}$ b) $\sqrt{1-\frac{1}{n^2}}$ c) $1-\frac{1}{n^2}$ d) $\frac{1}{2-n^2}$

114. In the situation shown in the figure, all the strings are light and inextensible and pullies are light. There is no friction at any surface and all blocks are of cuboidal shape. A horizontal force of magnitude F is applied to right most free end of string in both cases shown in the figure. 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 (a) and figure (b) be a_1 and a_2, respectively. Then,



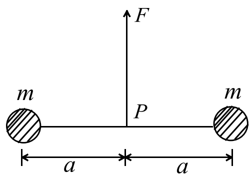
a) $a_1=a_2\neq 0$ b) $a_1=a_2=0$ c) $a_1>a_2$ d) $a_1<a_2$

115. In the figure, a block of weight 60 N is placed on a rough surface. The coefficient of friction between the block and the surface is 0.5. What minimum can be the weight W such that the block does not slip on the surface?



a) 60 N b) $\frac{60}{\sqrt{2}}$ N c) 30 N d) $\frac{30}{\sqrt{2}}$ N

116. The 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 a distance 'a' from the center 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 becomes $2x$, is

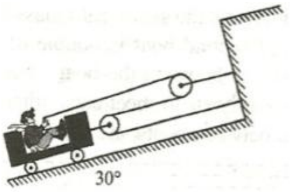


a) $\frac{F}{2m}\frac{a}{\sqrt{a^2-x^2}}$ b) $\frac{F}{2m}\frac{x}{\sqrt{a^2-x^2}}$ c) $\frac{F}{2m}\frac{x}{a}$ d) $\frac{F}{2m}\frac{\sqrt{a^2-x^2}}{x}$

117. n Balls each of mass m impinge elastically each second on a surface with velocity$u$. The average force experienced by the surface will be

a) mnu b) $2\ mnu$ c) $4\ mnu$ d) $mnu/2$

118. A man pulls himself up the 30° incline by the method shown. If the combined mass of the man and cart is 100 kg, determine the acceleration of the cart if the man exerts a pull of 250 N on the rope. Neglect all friction and the mass of the rope, pulleys, and wheels



a) 4.5 ms^{-2} b) 2.5 ms^{-2} c) 3.5 ms^{-2} d) 1.5 ms^{-2}

119. A block compartment containing gas is moving with some acceleration in horizontal direction. Neglect effect of gravity. Then the pressure in the compartment is

a) Same everywhere b) Lower in front side c) Lower in rear side d) Lower in upper side

120. A particle of mass 2 kg moves with an initial velocity of $(4\hat{\imath}+2\hat{\jmath})ms^{-1}$ on the $x-y$ plane. A force $\vec{F}=(2\hat{\imath}-8\hat{\jmath})$N acts on the particle. The initial position of the particle is (2 m, 3 m). Then for $y=3$ m,

a) Possible value of x is only $x=2$ m b) Possible value of x is not only $x=2$ m, but there exists some other value of x also

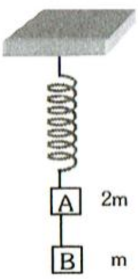
c) Time taken is 2 s d) All of the above

121. A monkey of mass 40 kg climbs on a massless rope of breaking strength 600 N. The rope will break if the monkey

a) Climbs up with a uniform speed of 5 ms^{-1} b) Climbs up with an acceleration of 6 ms^{-2}

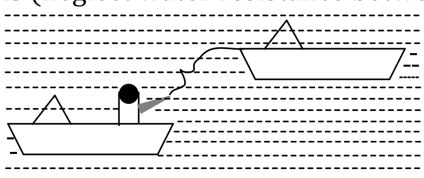
c) Climbs down with an acceleration of 4 ms^{-2} d) Climbs down with a uniform speed of 5 ms^{-2}

122. Two blocks A and B of masses $2m$ and m, respectively, are connected by a massless and inextensible string. The whole system is suspended by a massless spring as shown in the figure. The magnitudes of acceleration of A and B , immediately after the spring is cut, are respectively



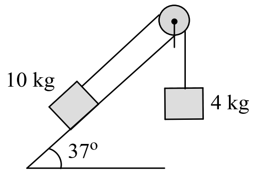
a) $g, g/2$ b) $g/2, g$ c) g, g d) $g/2, g/2$

123. A rope is stretched between two boats at rest. A sailor in the first boat pulls the rope with a constant force of 100 N. first boat with the sailor has a mass of 250 kg whereas the mass of second boat is double of this mass. If the initial distance between the boats was 100 m, the time taken for two boats to meet each other is (neglect water resistance between boats and water)



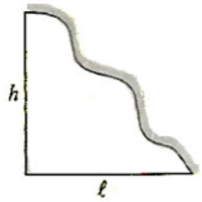
a) 13.8 s b) 18.3 s c) 3.18 s d) 31.8 s

124. A system of two blocks, a light string, and a light and frictionless pulley is arranged as shown in the figure. The coefficient of friction between fixed incline and 10 kg block is given by $\mu_s = 0.27$ and $\mu_k = 0.20$. If the system is released from rest, then find the acceleration of 10 kg block



a) Zero b) 0.114 ms^{-2} c) 0.228 ms^{-2} d) 2.97 ms^{-2}

125. A uniform chain is placed at rest on a rough surface of base length l and height h on an irregular as shown. Then, the minimum coefficient of friction between the chain and the surface must be equal to



a) $\mu = \frac{h}{2\ell}$ b) $\mu = \frac{h}{\ell}$ c) $\mu = \frac{3h}{2\ell}$ d) $\mu = \frac{2h}{3\ell}$

126. A particle of small mass m is joined to a very heavy body by a light string passing over a light pulley. Both bodies are free to move. The total downward force on the pulley is

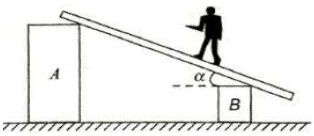
a) $>> mg$ b) $4\, mg$ c) $2\, mg$ d) mg

127. A wooden block of mass M resting on a rough horizontal floor is pulled with a force F at an angle ϕ with the horizontal. If μ is the coefficient of kinetic friction between the block and the surface, then the acceleration of the block is

a) $\frac{F}{M}(\cos\phi - \mu\sin\phi) - \mu g$ b) $\frac{\mu F}{M}\cos\phi$

c) $\frac{F}{M}(\cos\phi + \mu\sin\phi) - \mu g$ d) $\frac{F}{M}\sin\phi$

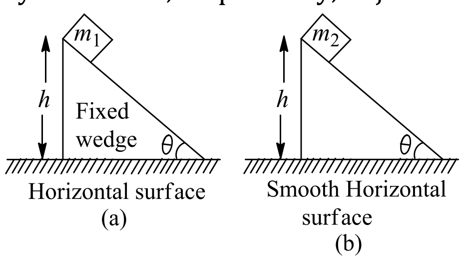
128. A plank is held at an angle α to the horizontal on two fixed supports A and B. The plank can slide against the supports (without friction) because of the weight $Mg\sin\alpha$. Acceleration and direction in which a man of mass m should move so that the plank does not move are



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

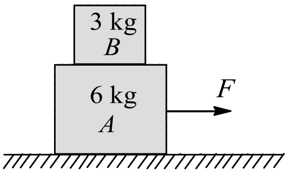
c) $g\sin\alpha\left(1+\frac{m}{M}\right)$ up the incline d) $g\sin\alpha\left(1+\frac{M}{m}\right)$ up the incline

129. A block of mass m_1 lies on the top of fixed wedge as shown in figure (a) and another block of mass m_2 lies on top of wedge which is free to move as shown in figure (b). 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 the blocks, respectively, to just reach the horizontal surface



a) $T_1 > T_2$ b) $T_1 < T_2$ c) $T_1 = T_2$ d) Data insufficient

130. Two blocks A and B of masses 6 kg and 3 kg rest on a smooth horizontal surface as shown in the figure. If coefficient of friction between A and B is 0.4, the maximum horizontal force which can make them move without separation is

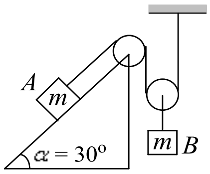


a) 72 N b) 40 N c) 36 N d) 20 N

131. Two persons are holding a rope of negligible weight tightly at its ends so that it is horizontal. A 15 kg weight is attached to the rope at the midpoint which now no longer remains horizontal. The minimum tension required to completely straighten the rope is

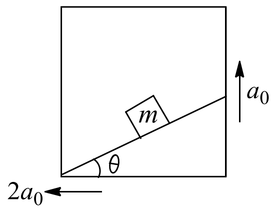
a) 15 kg b) 12/2 kg c) 5 kg d) Infinitely large

132. In an arrangement shown below, the acceleration of block A an B are



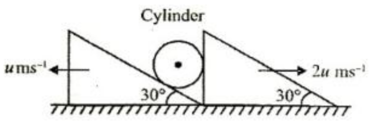
a) g/3, g/6 b) g/6, g/3 c) g/2, g/2 d) 0, 0

133. For the situation shown in figure, the block is stationary w.r.t. incline fixed in an elevator. The elevator is having an acceleration of $\sqrt{5}a_0$ whose components are shown in the figure. The surface is rough and coefficient of static friction between the incline and block isμ_s. Determine the magnitude of force exerted by incline on the block. (take $a_0 = \frac{g}{2}$ and $\theta = 37°, \mu_s = 0.2$)



a) $\frac{mg}{10}$ b) $\frac{9mg}{25}$ c) $\frac{3mg}{25} \times \sqrt{41}$ d) $\frac{\sqrt{13}\,mg}{2}$

134. A system is shown in the figure. Assume that cylinder remains in contact with the two wedge, then the velocity of cylinder is



a) $\sqrt{19 - 4\sqrt{3}}$ ms^{-1} b) $\frac{\sqrt{13}u}{2}$ ms^{-1} c) $\sqrt{3}$ u ms^{-1} d) $\sqrt{7}$ ms^{-1}

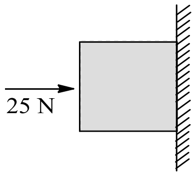
135. If the resultant of all the external forces acting on a system of particles is zero, then form an inertial frame, one can surely say that

a) Linear momentum of the system does not change in time
b) Kinetic energy of the system does not change in time
c) Angular momentum of the system does not change in time
d) Potential energy of the system does not change in time

136. 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

a) $2\tan\phi$ b) $\tan\phi$ c) $2\sin\phi$ d) $2\cos\phi$

137. A horizontal force of 25 N is necessary to just hold a block stationary against a wall. The coefficient of friction between the block and the wall is 0.4. The weight of the block is

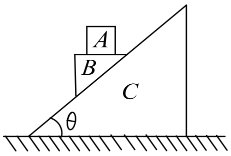


a) 2.5 N b) 20 N c) 10 N d) 5 N

138. 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 of10 ms^{-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 $\mathrm{g} = 10\ \mathrm{ms}^{-2}$)

a) $10\ \mathrm{ms}^{-2}$ b) $10\sqrt{2}\ \mathrm{ms}^{-2}$ c) $20\ \mathrm{ms}^{-2}$ d) Zero

139. In the figure shown, all blocks are of equal mass$m$. All surfaces are smooth, the acceleration of B w.r.t. ground is

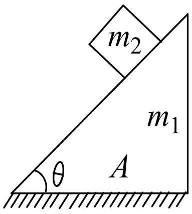


a) $\dfrac{2g\sin\theta}{1+3\sin^2\theta}$ b) $\dfrac{4g\sin\theta}{1+3\sin^2\theta}$ c) $\dfrac{2g\sin\theta}{\sqrt{1+3\sin^2\theta}}$ d) $\dfrac{4g\sin\theta}{\sqrt{1+3\sin^2\theta}}$

140. 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 stays at rest with respect to the wire, from the y-axis is

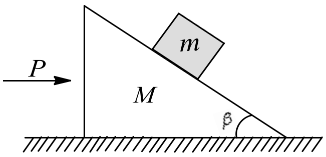
a) $\dfrac{a}{gk}$ b) $\dfrac{a}{2gk}$ c) $\dfrac{2a}{gk}$ d) $\dfrac{a}{4gk}$

141. In the given figure, the mass m_2 starts with velocity v_0 and moves with constant velocity on the surface. During motion the normal reaction between the horizontal surface and fixed triangle block m_1 is$N$. Then during motion



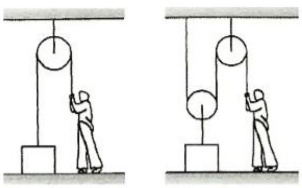
a) $N = (m_1 + m_2)\mathrm{g}$ b) $N = m_1\mathrm{g}$ c) $N < (m_1 + m_2)\mathrm{g}$ d) $N > (m_1 + m_2)\mathrm{g}$

142. Two wooden blocks are moving on a smooth horizontal surface such that the mass m remains stationary with respect to block of mass M as shown in the figure. The magnitude of force P is



a) $(M + m)\mathrm{g}\tan\beta$ b) $\mathrm{g}\tan\beta$ c) $m\mathrm{g}\cos\beta$ d) $(M + m)\mathrm{g}\,\mathrm{cosec}\,\beta$

143. In the figure shown, a person wants to rise 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

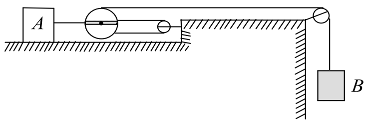


a) (i) b) (ii)

c) Same in both

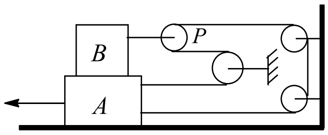
d) Cannot be determined

144. A block A has a velocity of 0.6 ms^{-1} to the right, determine the velocity of cylinder B



a) 1.2 ms^{-1} b) 2.4 ms^{-1} c) 1.8 ms^{-1} d) 3.6 ms^{-1}

145. In the figure, the string does not slip on pulley$P$, but pulley P is free to rotate about its own axis. Block A is displaced towards left, then pulley P



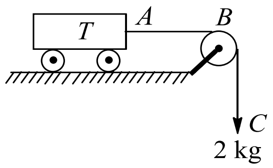
a) Rotates clockwise and translates

b) Rotates anticlockwise and translates

c) Only translates

d) Only rotates (clockwise or anticlockwise)

146. A trolley T of mass 5 kg on a horizontal smooth surface is pulled by a load of 2 kg through a uniform rope ABC of length 2 m and mass 1 kg. as the load falls from $BC = 0$ to $BC = 2$ m, its acceleration (in ms^{-2}) changes from

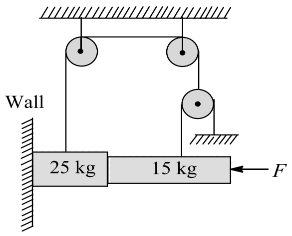


a) $\frac{20}{6}$ to $\frac{30}{6}$ b) $\frac{20}{8}$ to $\frac{30}{8}$ c) $\frac{20}{5}$ to $\frac{30}{6}$ d) None of these

147. In the above problem, contact force between man and the crate is

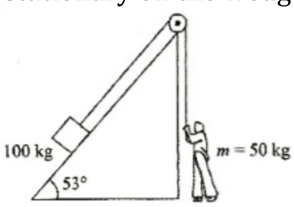
a) 2250 N b) 1125 N c) 750 N d) 375 N

148. If the coefficient of friction between all surfaces (for the shown diagram) is 0.4, then find the minimum force F to have equilibrium of the system



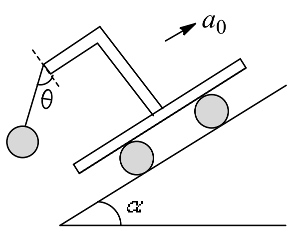
a) 62.5 N b) 150 N c) 31.25 N d) 50 N

149. 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 ms^{-2})



a) 2 ms^{-1} b) 4 ms^{-2} c) 6 ms^{-2} d) 8 ms^{-2}

150. 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



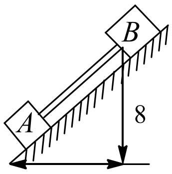
a) $\theta = \tan^{-1} \alpha$

b) $\theta = \tan^{-1} \left(\frac{a_0}{g}\right)$

c) $\theta = \tan^{-1} \left(\frac{g}{a_0}\right)$

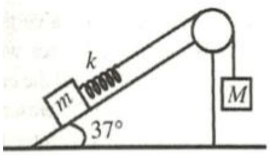
d) $\theta = \tan^{-1} \left(\frac{a_0 + g \sin \alpha}{g \cos \alpha}\right)$

151. Blocks A and B in the figure are connected by a bar of negligible weight. Mass of each block is 17 kg and $\mu_A = 0.2$ and $\mu_B = 0.4$, where μ_A and μ_B are the coefficients of limiting friction between blocks and plane, calculate the force developed in the bar (g=10 ms^{-2})



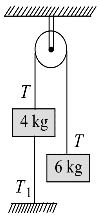
a) 150 N
b) 75 N
c) 200 N
d) 250 N

152. A block of mass m is attached with a massless spring of force constant$k$. The block is placed over a rough inclined surface for which the coefficient of friction is 0.5 M is released from rest when the spring was unstretched. The minimum value of M required to move the block m up the plane is (neglect mass of string and pulley and friction in pulley)



a) $m/2$
b) $m/3$
c) $m/4$
d) None of these

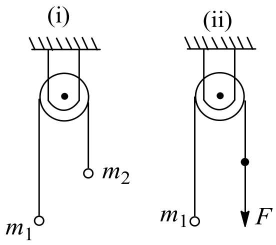
153. Two bodies of masses 4 kg and 6 kg are attached to the ends of a string passing over a pulley. The 4 kg mass is attached to the table top by another string. The tension in this string T_1 is equal to (take $g = 10$ ms^{-2})



a) 20 N
b) 25 N
c) 10.6 N
d) 10 N

154. In two pulley-particle systems (i) and (ii), the acceleration and force imparted by the string on the pulley and tension in the strings are (a_1, a_2), (N_1, N_2) and (T_1, T_2), respectively. Ignoring friction in all contacting surfaces

Study the following statements :



I. $\frac{a_1}{a_2} = 1$ (ii) $\frac{T_1}{T_2} < 1$ (iii) $\frac{N_1}{N_2} > 1$ (iv) $\frac{a_1}{a_2} < 1$

Now mark correct answer:

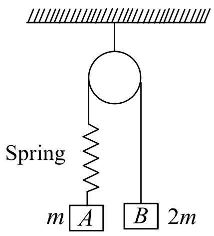
a) Relations (ii) and (iii) always follow

b) Relations (ii) and (iv) always follow

c) Only relation (i) always follows

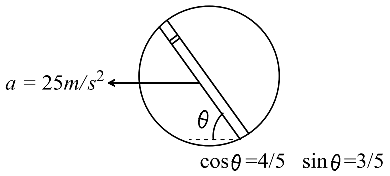
d) Only relation (iv) always follows

155. Two blocks A and B of masses m and2 m, respectively, are held at rest such that the spring is in natural length. Find out the accelerations of both the blocks just after release



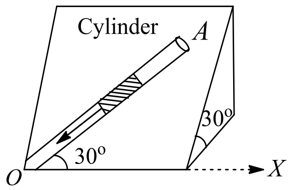
a) g ↓, g ↓ b) $\frac{g}{3}\downarrow, \frac{g}{3}\uparrow$ c) 0, 0 d) g ↓, c

156. A circular disc with a groove along its diameter is placed horizontally. A block of mass $1kg$ is placed as shown. The co-efficient of friction between the block and all surfaces of groove in contact is $\mu = 2/5$. The disc has an acceleration of 25 m/s^2. Find the acceleration of the block with respect to disc



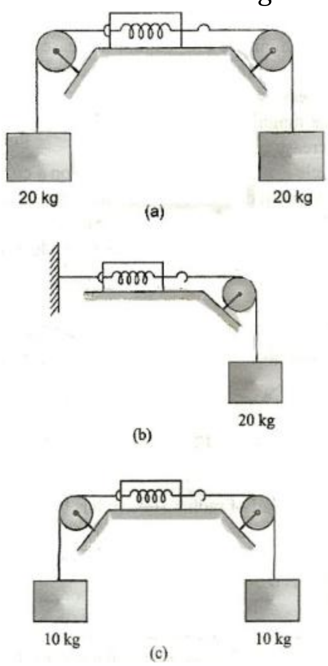
a) 10 m/s^2 b) 5 m/s^2 c) 20 m/s^2 d) 1 m/s^2

157. An inclined plane makes an angle 30° with the horizontal. A groove (OA) of length = 5m cut in the plane makes an angle 30° withOX. A short smooth cylinder is free to slide down under the influence of gravity. The time taken by the cylinder to reach from A to O is (g = 10 ms^{-2})



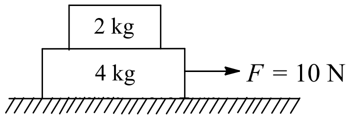
a) 4 s b) 2 s c) 3 s d) 1 s

158. Three arrangement of a light spring balance are shown in the following figure. The reading of the spring scales in three arrangements are, respectively,



a) 20 g, 20 g, 10 g b) 20 g, 20 g, $\frac{40}{3}$ g c) Zero, 20 g, 10 g d) Zero, 20 g, $\frac{40\text{ g}}{3}$

159. In the given figure, the blocks are at rest and a force 10 N act on the block of 4 kg mass. The coefficient of static friction and the coefficient of kinetic friction are $\mu_s = 0.2$ and $\mu_k = 0.15$ for both the surface in contact. The magnitude of friction force acting between the surface of contact between the 2 kg and 4 kg block in this situation is



a) 3 N b) 4 N c) 3.33 N d) Zero

160. A flat plate moves normally with a speed v_1 towards a horizontal jet of water of uniform area of cross-section. The jet discharges water at the rate of volume V per second at a speed of v_2. The density of water is ρ. Assume that water splashes along the surface of the plate at right angles to the original motion. The magnitude of the force acting on the plate due to the jet of water is

a) $\rho V v_1$ b) $\rho V(v_1 + v_2)$ c) $\frac{\rho V}{v_1 + v_2} v_1^2$ d) $\rho \left[\frac{V}{v_2}\right](v_1 + v_2)^2$

161. An intersteller spacecraft far away from the influence of any star or planet is moving at high speed under the influence of fusion rockets (due to thrust exerted by fusion rockets, the spacecraft is acceleration). Suddenly the engine malfunctions and stops. The spacecraft will

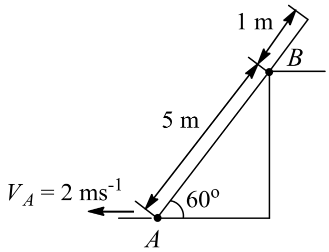
a) Immediately stop, throwing all of the occupants to the front

b) Begin slowing down and eventually come to rest

c) Keep moving at constant speed for a while, and then begin to slow down

d) Keep moving forever with constant speed

162. Velocity of point A on the rod 2 ms^{-1} (leftwards) at the instant shown in the figure. The velocity of the point B on the rod at this instant is

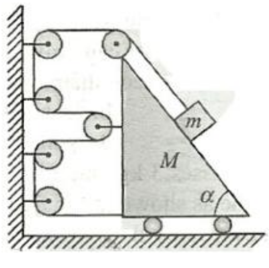


a) $\frac{2}{\sqrt{3}}\text{ms}^{-1}$ b) $1\ \text{ms}^{-1}$ c) $\frac{1}{2\sqrt{3}}\text{ms}^{-1}$ d) $\frac{\sqrt{3}}{2}\text{ms}^{-1}$

163. Two skaters have weight in the ratio 4:5 and are 9 m apart, on a smooth frictionless surface. They pull on a rope stretched between them. The ratio of the distance covered by them when they meet each other will be

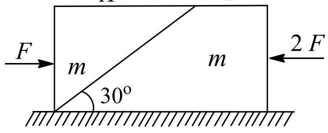
a) 5: 4 b) 4: 5 c) 25: 16 d) 16: 25

164. If the acceleration of wedge in the shown arrangement a ms^{-2} towards left, then at this instant acceleration of the block (magnitude only) would be



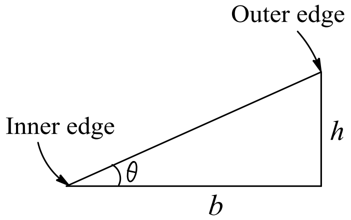
a) $4\ a\ \text{ms}^{-2}$ b) $a\sqrt{17 - 8\cos\alpha}\ \text{ms}^{-2}$ c) $(\sqrt{17})a\ \text{ms}^{-2}$ d) $\sqrt{17}\cos\frac{\alpha}{2} \times a\ \text{ms}^{-2}$

165. Two bodies A and B each of mass m are placed on a smooth horizontal surface. Two horizontal force F and 2 F are applied on the blocks A and B, respectively, as shown in the figure. The block A does not slide on block B. Then the normal reaction acting between the two blocks is (assume no friction between the blocks)



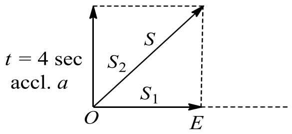
a) F b) $F/2$ c) $\frac{F}{\sqrt{3}}$ d) $3F$

166. A vehicle is moving with a velocity v on a curved road of width b and radius of curvature R. For counteracting the centripetal force on the vehicle, the difference in elevation required in between the outer and inner edges of the rod is



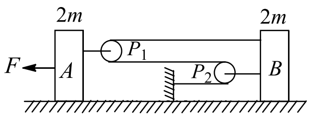
a) v^2b/Rg b) vb/Rg c) vb^2/Rg d) vb/R^2g

167. A body of mass 2 kg has an initial velocity of 3 ms^{-1} along OE and it is subjected to a force of 4 N in a direction perpendicular toOE. The distance of body from O after 4 s will be



a) 12 m b) 20 m c) 8 m d) 48 m

168. The acceleration of the block B in the following figure, assuming then surfaces and the pulleys P_1 and P_2 are all smooth is



a) $\frac{F}{4m}$ b) $\frac{3F}{13m}$ c) $\frac{F}{2m}$ d) $\frac{3F}{17m}$

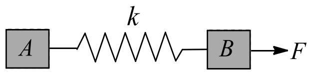
169. A lift is moving down with an acceleration a. A man in the lift drops a ball inside the lift. The acceleration of the ball as observed by the man standing stationary on the ground are, respectively,

a) a, g b) (g − a); g c) a, a d) g, g

170. A wooden box is placed on a table. The normal force on the box from the table isN_1. Now another identical box is kept on first box and the normal force on lower block due to upper block is N_2 and normal force on lower block by the table isN_3. For this situation mark out the correct statement (s)

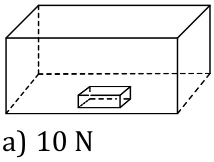
a) $N_1 = N_2 = N_3$ b) $N_1 < N_2 = N_3$ c) $N_1 = N_2 < N_3$ d) $N_1 = N_2 > N_3$

171. Two identical particles A and$B$, each of mass m, are interconnected by a spring of stiffness k. If the particles B experience a force F and the elongation of the spring is x, the acceleration of particles B relative to particle A is equal to



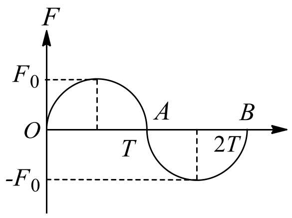
a) $\frac{F}{2m}$ b) $\frac{F-kx}{m}$ c) $\frac{F-2kx}{m}$ d) $\frac{kx}{m}$

172. A solid block of mass 2 kg is resting inside a cube as shown in the figure. The cube is moving with a velocity$\vec{v} = 5\hat{\imath} + 2\hat{\jmath}$ ms^{-1}. If the coefficient of friction between the surface of cube and block is 0.2, then the force of friction between the block and cube is



a) 10 N b) 4 N c) 14 N d) Zero

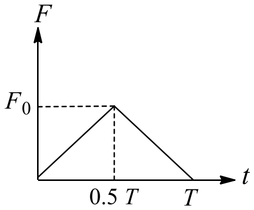
173. A unidirectional force F varying with time t as shown in the figure acts on a body initially at rest for a short duration2 T. Then the velocity acquired by the body is



a) $\dfrac{\pi F_0 T}{4m}$ b) $\dfrac{\pi F_0 T}{2m}$ c) $\dfrac{F_0 T}{4m}$ d) Zero

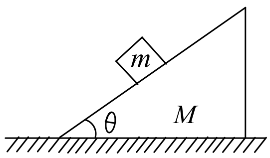
174. An object is suspended from a spring balance in a lift. The reading is 240 N when the lift is at rest. If the spring balance reading now changes to 220 N, then the lift is moving
a) Downward with constant speed b) Downward with decreasing speed
c) Downward with increasing speed d) Upward with increasing speed

175. A ball of mass m moving with a velocity u rebounds from a wall. The collision is assumed to be elastic and the force of interaction between the ball and wall varies as shown in the figure. Then the value of F_0 is



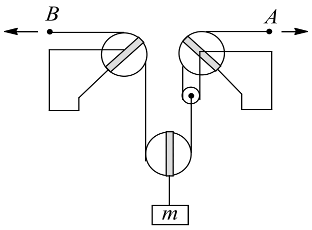
a) mu/T b) 2 mu/T c) 4 mu/T d) $mu/2\ T$

176. In the figure shown, the block of mass m is at rest relative to the wedge of mass $M$and the wedge is at rest with respect to ground. This implies that



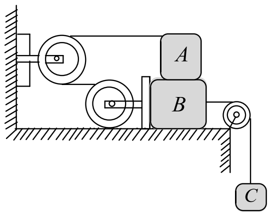
a) Net force applied by m on M is mg b) Normal force applied by m on M is mg
c) Force of friction applied by m on M is mg d) None of the above

177. For the pulley system shown, each of the cables at A and B is given a velocity of 2 ms^{-1} in the direction of the arrow. Determine the upward velocity v of the load m



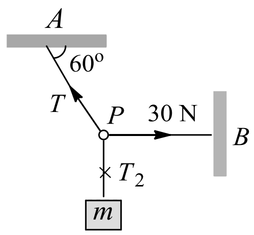
a) 1.5 ms^{-1} b) 3 ms^{-1} c) 6 ms^{-1} d) 4.5 ms^{-1}

178. The maximum value of mass of block C so that neither A nor B moves is (Given that mass of A is 100 kg and that of B is 140 kg. Pulleys are smooth and friction coefficient between A and b and between B and horizontal surface is$\mu = 0.3$). take $\text{g} = 10\ \text{ms}^{-2}$



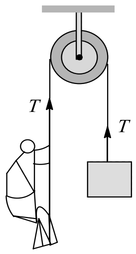
a) 210 kg b) 190 kg c) 185 kg d) 162 kg

179. Three light strings are connected at the point$P$. A weight W is suspended from one of the string. End A of string AP and end B of string PB are fixed as shown. In equilibrium, PB is horizontal and PA makes an angle of 60° with the horizontal. If the tension in PB is 30 N, then the tension in PA and weight W are, respectively, given by



a) 60 N; 30 N b) $60/\sqrt{3}$; $30\sqrt{3}$ N c) 60 N; $30\sqrt{3}$ N d) $60\sqrt{3}$; $30\sqrt{3}$ N

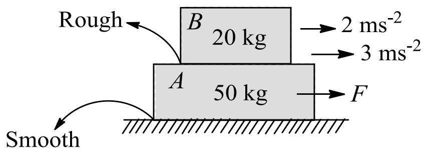
180. If the resultant of all the external forces acting on a system of particles is zero, then from an inertial frame, one can surely say that
    a) Liner momentum of the system does not change in time
    b) Kinetic energy of the system does not change in time
    c) Angular momentum of the system does not change in time
    d) Potential energy of the system does not change in time
181. In order to raise a mass of 100 kg, a man of mass 60 kg fastens a rope to its and passes the rope over a smooth pulley. He climbs the rope with acceleration 5 $g/4$ relative to the rope. The tension in the rope is (take $\mathrm{g} = 10\ \mathrm{ms}^{-2}$)



a) $\frac{4875}{8}$ N b) $\frac{4875}{2}$ N c) $\frac{4875}{4}$ N d) $\frac{4875}{6}$ N

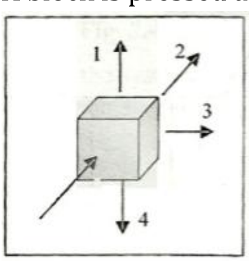
Multiple Correct Answers Type

182. A 20 kg black is placed on top of 50 kg block as shown. An horizontal force F acting on A cause an acceleration of 3 ms^{-2} to A and 2 ms^{-2} to B as shown. For this situation, mark out the correct statement (s)



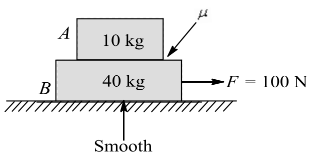
a) The friction force between A and B is 40 N b) The net force acting on A is 150 N
c) The value of F is 190 N d) The value of F is 150 N

183. A block is pressed against a vertical wall as shown in the figure



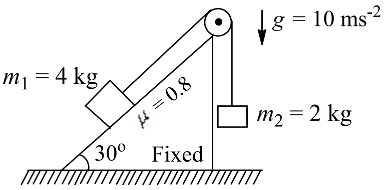
a) It is most easier to slide the block along 4
b) It is most difficult to slide the block along 1
c) It is equally easier or difficult to slide the block in any direction
d) It is most difficult to slide the block along 3

184. A 10 kg block is placed on top of 40 kg block as shown. A horizontal force F acting on B causes an acceleration of 2 ms^{-2} to$B$. For this situations mark out the correct statement(s)



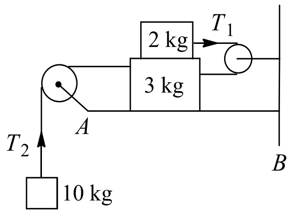
a) The acceleration of A may be 2 ms^{-2} or less than 2 ms^{-2}
b) The acceleration of A must also be 2 ms^{-2}
c) The coefficient of friction between the blocks may be 0.2
d) The coefficient of friction between the blocks must be 0.2 only

185. Two blocks of masses m_1 and m_2 are connected through a massless inextensible string. Block of mass m_1 is placed at the fixed rigid inclined surface while the block of mass m_2 hanging at the other end of the string, which is passing through a fixed massless frictionless pulley shown in the figure. The coefficient of static friction between the block and the inclined plane is 0.8. the system of masses m_1 and m_2 is released from rest



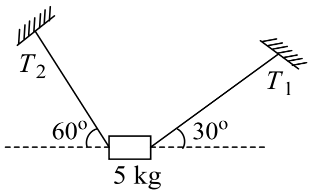
a) The tension in the string is 20 N after releasing the system
b) The contact force by the inclined surface on the block is along normal to the inclined surface
c) The magnitude of contact force by the inclined surface on the block m_1 is $20\sqrt{3}$ N
d) None of these

186. Coefficient of friction between the two blocks is 0.3. Whereas the surface AB is smooth



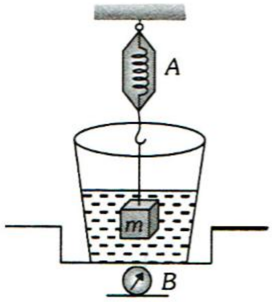
a) Acceleration of the system of masses is $88/15$ ms^{-2}
b) Net force acting on 3 kg mass is greater than that on 2 kg mass
c) Tension $T_2 > T_1$
d) Since 10 kg mass is acceleration downwards, so net force acting on it should be greater than any of the two blocks shown in the figure

187. A body of mass 5 kg is suspended by the strings making angles 60° and 30° with the horizontal as shown in the figure($g = 10$ ms^{-2}). Then



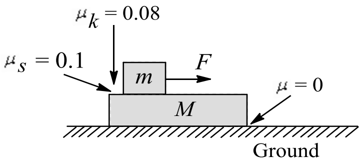
a) $T_1 = 25$ N b) $T_2 = 25$ N c) $T_1 = 25\sqrt{3}$ N d) $T_2 = 25\sqrt{3}$ N

188. The spring balance A reads 2 kg with a block m suspended from it. A balance B reads 5 kg when a beaker filled with liquid is put on the pan of the balance. The two balances are now so arranged that the hanging mass is inside the liquid as shown in figure. In this situation



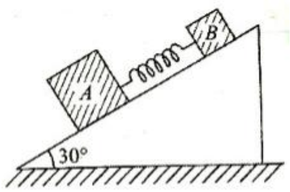
a) The balance A will read more than 2 kg
b) The balance B will read more than 5 kg
c) The balance A will read less than 2 kg and B will read more than 5 kg
d) The balances A and B will read 2 kg and 5 kg respectively

189. In the figure, if $F = 4$ N, $m = 2$ kg, $M = 4$ kg, then



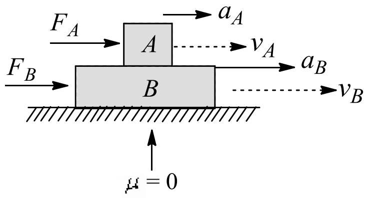
a) The acceleration of m w.r.t. ground is $\frac{2}{3}$ ms^{-2}
b) The acceleration of m w.r.t. ground is 1.2 ms^{-2}
c) Acceleration of M is 0.4 ms^{-2}
d) Acceleration of M w.r.t. ground is $\frac{2}{3}$ ms^{-2}

190. Two blocks A and B of masses 5 kg and 2 kg, respectively, connected by spring of force constant= 100 Nm^{-1} are placed on an inclined plane of inclination 30° as shown in figure. If the system is released from rest



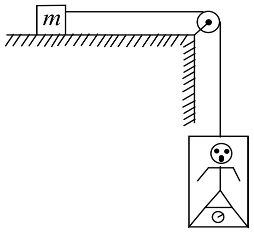
a) There will be no compression or elongation in the spring if all surfaces are smooth
b) There will be elongation in the spring if A is rough and B is smooth
c) Maximum elongation in the spring 35 cm if all surfaces are smooth
d) There will be elongation in the spring if A is smooth and B is rough

191. Two rough blocks A and B, A placed over B, move with acceleration $\vec{a}_A$ and $\vec{a}_B$,, velocities $\vec{v}_A$ and $\vec{v}_B$ by the action of horizontal forces $\vec{F}_A$ and $\vec{F}_B$, respectively. When no friction exists between the blocks A and B,



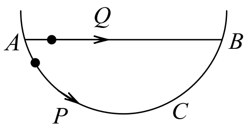
a) $v_A = v_B$
b) $a_A = v_B$
c) Both **a.** and **b.**
d) $\frac{F_A}{m_A} = \frac{F_B}{m_B}$

192. In the figure, a man of true mass M is standing on a weighing machine placed in a cabin. The cabin is joined by a string with a body of mass$m$. Assuming no friction, and negligible mass of cabin and weighing machine, the measured mass of man is (normal force between the man and the machine is proportional to the mass)



a) Measured mass of man is $\frac{Mm}{(M+m)}$
b) Acceleration of man is $\frac{mg}{(M+m)}$
c) Acceleration of man is $\frac{Mg}{(M+m)}$
d) Measured mass of man is M

193. A particle P is sliding down a frictionless hemispherical bowl. It passes the point A at $t = 0$. At this instant of time, the horizontal component of its velocity is v. A bead Q of the same mass as P is ejected from A at $t = 0$ along the horizontal string AB, with the speed v. Friction between the bead and the string may be neglected. Let t_p and t_Q be the respective times taken by P and Q to reach the point B. Then



a) $t_P < t_Q$
b) $t_P = t_Q$
c) $t_P > t_Q$
d) $\frac{t_P}{t_Q} = \frac{\text{Length of arc } ACB}{\text{Length of } AB}$

194. A ship of mass 3×10^7 kg, initially at rest, is pulled by a force of 5×104 N through a distance of 3 m. Assuming that the resistance due to water is negligible, the speed of the ship is
a) 1.5 ms^{-1}
b) 60 ms^{-1}
c) 0.1 ms^{-1}
d) 5 ms^{-1}

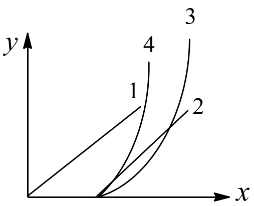
195. A reference frame attached to the Earth
a) In an inertial frame by definition
b) Cannot be an inertial frame because the Earth in revolving round the Sun
c) Is an inertial frame because Newton's laws are applicable in thus frame
d) Cannot be an inertial frame because the Earth is rotating about its own axis

196. Which of the following statement (s) can be explained by Newton's second law of motion?
a) To stop of heavy body (say truck), much greater force is needed than to stop a light body (say motorcycle), in the same time, if they are moving with the same speed
b) For a given body, the greater the speed, the greater the opposing force needed to stop the body in a certain time
c) To change the momentum (given), the force required is independent of time
d) The same forces acting on two different bodies for same time cause the same change in momentum in the bodies

197. A gardner waters the plants by a pipe of diameter 1 mm. The water comes out at the rate or 10 cm^3s^{-1}. The reactionary force exerted on the hand of the gardner is
a) Zero
b) 1.27×10^{-2} N
c) 1.27×10^{-4} N
d) 0.127 N

198. A block of mass 2 kg rests on a rough inclined plane making an angle of 30° with horizontal. The coefficient of static friction between the block and the plane is 0.7. The frictional force on the block is
a) 9.8 N
b) $0.7 \times 9.8 \times \sqrt{3}$ N
c) $9.8 \times \sqrt{3}$ N
d) 0.7×9.8 N

199. A block is resting over a rough horizontal floor. At$t = 0$, a time-varying force starts acting on it, the force is described by equation$F = kt$, where k is constnst and t is in second. Mark the correct statement (s) for this situation

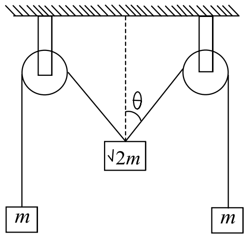


a) Curve 1 shows acceleration-time graph
b) Curve 2 shows acceleration-time graph
c) Curve 3 shows velocity-time graph
d) Curve 4 shows displacement-time graph

200. A golf ball of mass 0.05 kg placed on a tee, is struck by a golf club. The speed of the gold ball as it leaves the tee is 100 ms^{-1}, the time of contact between them is 0.02 s. If the force decreases to zero linearly with time, then the force at the beginning of the contact is

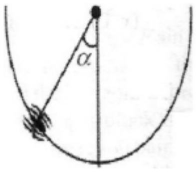
a) 5000 N
b) 250 N
c) 200 N
d) 100 N

201. The pulleys and strings shown in the figure are smooth and of negligible mass. For the system to remain in equilibrium, the angle θ shopuld be



a) 0°
b) 30°
c) 45°
d) 60°

202. An insect crawls up a hemispherical surface very slowly. The coefficient of friction between the insect and the surface is 1/3. If the line joining the centre of the hemispherical surface to the insect makes an angle α with the vertical, the maximum possible value of α is given by



a) $\cot \alpha = 3$
b) $\tan \alpha = 3$
c) $\sec \alpha = 3$
d) $\operatorname{cosec} \alpha = 3$

203. Which of the following are correct?

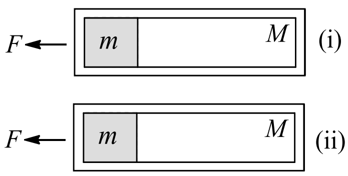
a) A parachutist of weight W strikes the ground with his legs and comes to rest with an upward acceleration of magnitude 3 g. force exerted on him by ground during landing is 4 W

b) Two massless spring balances are hung vertically in series from a fixed point and a mass M kg is attached to the lower end of the lower spring balance. Each spring balance reads M kgf

c) A rough vertical broad has an acceleration a along the horizontal direction so that a block of mass m pressing against its vertical side does not fall. The coefficient of friction between the block and the broad is greater than g/a

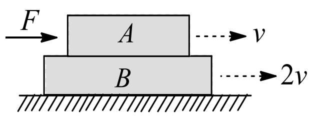
d) A man is standing at a spring platform. If man jumps away from the platform the reading of the spring balance first increases and then decreases to zero

204. A block of mass m is placed in contact with one end of a smooth tube of mass$M$. A horizontal force F acts in the tube in each case (i) and (ii). Then,



a) $a_m = 0$ and $a_M = \dfrac{F}{M}$ in (i)
b) $a_m = a_M = \dfrac{F}{M+m}$ in (i)
c) $a_m = a_M = \dfrac{F}{M+m}$ in (ii)
d) Force on m is $\dfrac{mF}{M+m}$ in (ii)

205. Two blocks A and B of masses m_A and m_B have velocity v and d2v, respectively, at a given instant. 000000A horizontal force F acts on the block$A$. There is no friction between ground and block B and coefficient of friction between A and B isμ. The friction

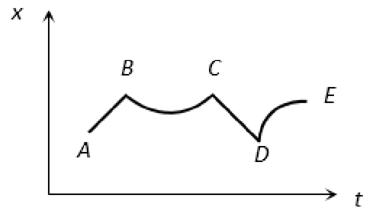


a) On A supports its motion
b) On B opposes its motion relative to A

c) On B opposes its motion
d) Opposes the motion of both

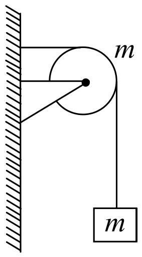
206. Mark the correct statement (s) regarding friction
a) Friction force can be zero, even through the contact surface is rough
b) Even though there is no relative motion between surfaces, frictional force may exist between them
c) The expression $f_L = \mu_s N$ or $f_k = \mu_k N$ are approximate expression
d) The expression $f_L = \mu_s N$ tells that the directions of f_L and N are the same

207. Figure shows the displacement of particle going along the X-axis as a function of time. The force acting on the particle is zero in the region



a) AB
b) BC
c) CD
d) DE

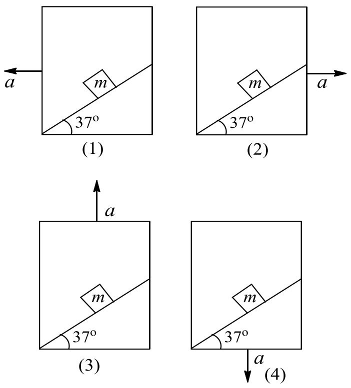
208. A string of negligible mass going over a clamped pulley of mass m supports a block of M as shown in figure. The force on the pulley by the clamp is given by



a) $\sqrt{2}\,Mg$
b) $\sqrt{2}\,Mg$
c) $(\sqrt{(M+m)^2+m})g$
d) $\left(\sqrt{(M+m)^2+M^2}\right)g$

209. A car is moving in a circular horizontal track of radius 10 m with a constant speed of 10 ms^{-1}. A plumb bob is suspended from the roof of the car by a light rigid rod. The angle made by the rod with the vertical is
a) Zero
b) 30°
c) 45°
d) 60°

210. 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 situations (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 the 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) $b_2 > b_3 > b_1 > b_4$

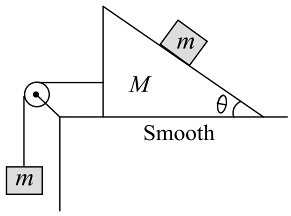
211. A 3 kg block of wood is on a level surface where $\mu_s = 0.25$ and $\mu_k = 0.2$. A force of 7 N is being applied horizontally to the block. Mark the correct statement (s) regarding this situation
a) If the block is initially at rest, it will remain at rest and friction force will be about 7 N
b) If the block is initially moving, then it will continue its motion forever if force applied is in the direction of motion of the block
c) If the block is initially moving and the direction of applied force is same as that of motion of block, then block moves with an acceleration of $1/3\ \text{ms}^{-2}$ along its initial direction of motion
d) If the block is initially moving and direction of applied force is opposite to that of initial motion of block,

then block decelerates, comes to a stop, and starts moving in the opposite direction

212. 80 railway wagons all of same mass 5×10^3 kg are pulled by an engine with a force of 4×10^5 N. The tension in the coupling between 30th and 31st wagon from the engine is

a) 25×10^4 N b) 40×10^4 N c) 20×10^4 N d) 32×10^4 N

213. The figure shows a block of mass m placed on a smooth wedge of mass M. Calculate the minimum value of M' and tension in the string, so that the block of mass m will move vertically downward with acceleration 10 ms^{-2}



a) The value of M' is $\frac{M \cot\theta}{1-\cot\theta}$

b) The value of M' is $\frac{M \tan\theta}{1-\tan\theta}$

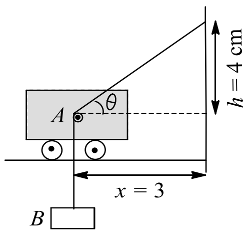
c) The value of tension in the string is $\frac{mg}{\tan\theta}$

d) The value of tension is , $\frac{Mg}{\cot\theta}$

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

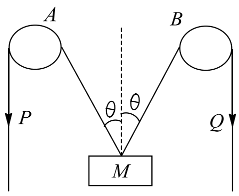
a) 2.5 N b) 0.98 N c) 4.9 N d) 0.49 N

215. The string shown in the figure is passing over small smooth pulley rigidly attached to trolley A. If the speed of trolley is constant and equal to v_A towards right, speed and magnitude of acceleration of block B at the instant shown in figure are



a) $v_B = v_A, a_B = 0$ b) $a_B = 0$ c) $v_B = \frac{3}{5} v_A$ d) $a_B = \frac{16 v_A^2}{125}$

216. In the arrangement shown in the figure, the ends P and Q of an unstretchable string move downwards with uniform speed U. Pulleys A and B are fixed



Mass M moves upwards with speed

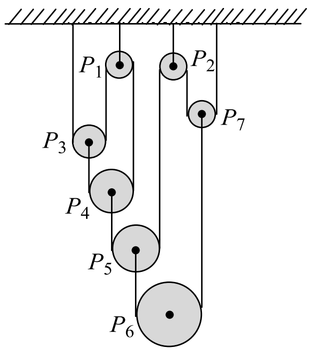
a) $2\,U \cos\theta$ b) $U/\cos\theta$ c) $2\,U/\cos\theta$ d) $U \cos\theta$

217. Suppose a body, which is acted on by exactly two forces, is accelerated. For this situation, mark the **incorrect** statement (s)

a) The body can't move with constant speed b) The velocity can never be zero

c) The vector sum of two forces can't be zero d) The two forces must act in the same line

218. Seven pulleys are connected with the help of three light strings as shown in the figure below. Consider P_3, P_4, P_5 as light pulleys and pulleys P_6 and P_7 have masses m each. For this arrangement, mark the correct statement (s)

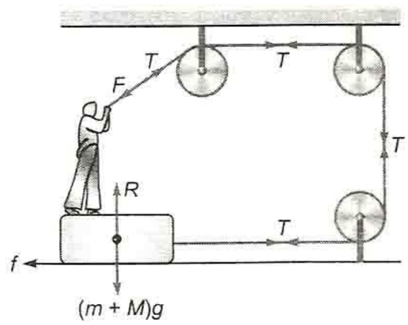


a) Tension in the string connecting P_1, P_3, and P_4 is zero
b) Tension in the string connecting P_1, P_3 and P_4 is $mg/3$
c) Tensions in all the three strings are same and equal to zero
d) Acceleration of P_6 is g downwards and that of P_7 is g upwards

219. If a dipole is situated in a non uniform field,

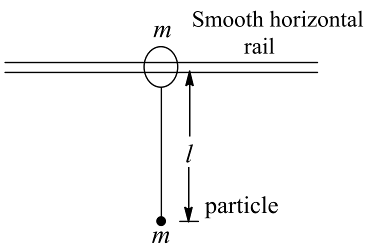
a) $\sum \vec{\mathbf{F}} = 0, \sum \vec{\tau} = 0$
b) $\sum \vec{\mathbf{F}} \neq 0$, but $\sum \vec{\tau} = 0$
c) $\sum \vec{\mathbf{F}} = 0$, but $\sum \vec{\tau} \neq 0$
d) $\sum \vec{\mathbf{F}} \neq 0, \sum \vec{\tau} \neq 0$

220. A man of mass M is standing on a board of mass m. The friction coefficient between the board and the floor is μ, figure. The maximum force that the man can exert on the rope so that the board does not move is



a) $\mu(m+M)g$
b) $\dfrac{\mu(m+M)g}{\mu+1}$
c) $\dfrac{\mu(m+M)g}{\mu-1}$
d) None of these

221. The ring shown in the figure is given a constant horizontal acceleration$(a_0 = g/\sqrt{3})$. Maximum deflection of the string from the vertical is θ_0, then

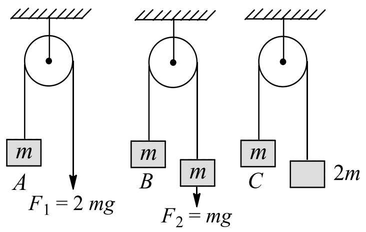


a) $\theta_0 = 30°$
b) $\theta_0 = 60°$
c) At maximum deflection, tension in string is equal to mg
d) At maximum deflection, tension in string is equal to $\frac{2mg}{\sqrt{3}}$

222. The accelerations of a particle as observed from two different frames S_1 and S_2 have equal magnitudes of $2\ \mathrm{ms^{-2}}$

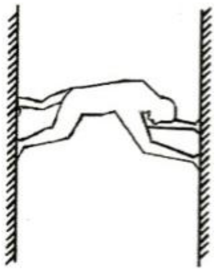
a) The relative acceleration of the frame may either be zero or $4\ \mathrm{ms^{-2}}$
b) Their relative acceleration may have any value between 0 and $4\ \mathrm{ms^{-2}}$
c) Both the frames may be stationary with respect to earth
d) The frames may be moving with same acceleration in same direction

223. In the figure, the blocks$A$, B, and C of mass m each have acceleration a_1, a_2, and a_3 , respectively. F_1 and F_2 are external forces of magnitude 2 mg and mg, respectively, then

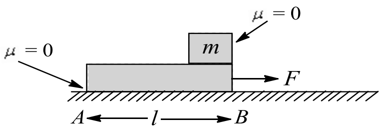


a) $a_1 \neq a_2 \neq a_3$ b) $a_1 = a_2 \neq a_3$ c) $a_1 > a_2 > a_3$ d) $a_1 \neq a_2 = a_3$

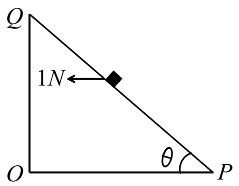
224. During paddling of a bicycle, the force of friction exerted by the ground on the two wheels is such that it acts
   a) In the backward direction on the front wheel and in the forward direction on the rear wheel
   b) In the forward direction on the front wheel and in the backward direction on the rear wheel
   c) In the backward direction on both the front and the rear wheels
   d) In the forward direction on both the front and the rear wheels
225. A man tires to remain in equilibrium by pushing with his hands and feet against two parallel walls. For equilibrium,



   a) The forces of friction at the two walls must be equal
   b) Friction must be present on both walls
   c) The coefficient of friction must be the same between both walls and the man
   d) None of the above
226. In the figure, a small block is kept on m, then



   a) The acceleration of m w.r.t. ground is $\frac{F}{m}$ b) The acceleration of m w.r.t. ground is zero
   c) The time taken by m to separate from M is $\sqrt{\frac{2\ell M}{F}}$ d) The time taken by m to separate from M is $\frac{2\ell M}{F}$
227. A small block of mass of 0.1 kg lies on a fixed inclined plane PQ which makes an angle θ with the horizontal. A horizontal force of 1 N acts on the block through its center of mass as shown in the figure. The block remains stationary if (take $g = 10\ m/s^2$)



   a) $\theta = 45°$
   b) $\theta > 45°$ and a frictional force acts on the block towards P
   c) $\theta > 45°$ and a frictional force acts on the block towards Q
   d) $\theta < 45°$ and a frictional force acts on the block towards Q

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 228 to 227. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

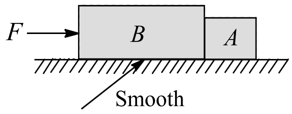
c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

228

Statement 1: In the figure shown below, ground is smooth and masses of both the blocks are different. Net force acting on each of the block is not same

Statement 2: Acceleration of both will be different



229

Statement 1: The work done in bringing a body down from the top to the base along a frictionless incline plane is the same as the work done in the bringing it down the vertical side

Statement 2: The gravitational force on the body along the inclined plane is the same as that along the vertical side

230

Statement 1: Force is required to move a body uniformly along a circle

Statement 2: When the motion is uniform, acceleration is zero

231

Statement 1: If the net external force on the body is zero, then its acceleration is zero

Statement 2: Acceleration does not depend on force

232

Statement 1: Frictional forces are conservative forces.

Statement 2: Potential energy can be associated with frictional forces.

233

Statement 1: Angle of repose is equal to angle of limiting friction

Statement 2: When the body is just at the point of motion, the force of friction in this stage is called as limiting friction

234

Statement 1: It is easier to pull a heavy object than to push it on a level ground

Statement 2: The magnitude of frictional force depends on the nature of the two surfaces in contact

235

Statement 1: A body in equilibrium has to be at rest only

Statement 2: A body in equilibrium may be moving with a constant speed along a straight line path

236

Statement 1: A block of mass m is placed on a smooth inclined plane of inclination θ with the horizontal. The force exerted by the plane on the block has a magnitude $mg\cos\theta$

Statement 2: Normal reaction always cats perpendicular to the contact surface

237

Statement 1: The acceleration of body sliding down a smooth plane of inclination 30 °is $5 ms^{-2}$.

Statement 2: Acceleration is given by a $=\mu g \sin\theta$.

238

Statement 1: Use of ball bearings between two moving parts of machine is a common practice

Statement 2: Ball bearings reduce vibrations and provide good stability

239

Statement 1: Inertia is the property by virtue of which the body is unable to change by itself the state of rest only

Statement 2: The bodies do not change their state unless acted upon by an unbalanced external force

240

Statement 1: Coefficient of friction can be greater than unity

Statement 2: Force of friction is dependent on normal reaction and ratio of force of friction and normal reaction cannot exceed unity

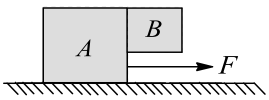
241

Statement 1: On a rainy day, it is difficult to drive a car or bus at high speed

Statement 2: The value of coefficient of friction is lowered due to wetting of the surface

242

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

243

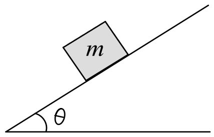
Statement 1: An electric fan continues to rotate for some time after the current is switched off

Statement 2: It is because of inertia of rest

244

Statement 1: A block is lying stationary as on inclined plane and coefficient of friction is μ. Friction on block is $\mu\, mg\cos\theta$

Statement 2: Contact force on block is mg



245

Statement 1: Linear momentum of a body changes even when it is moving uniformly in a circle

Statement 2: In uniform circular motion velocity remain constant

246

Statement 1: A concept of pseudo forces is valid both for inertial as well as non-inertial frame of reference

Statement 2: A frame accelerated with respect to an inertial frame is a non-inertial frame

247

Statement 1: A frame of reference which is moving with uniform velocity is non inertial frame of reference.

Statement 2: A reference frame in which Newton's laws of motion are applicable is non – inertial.

248

Statement 1: The apparent weight of a body in an elevator moving with some downward acceleration is less than the actual weight of body

Statement 2: The part of the weight is spent in producing downward acceleration, when body is in elevator

249

Statement 1: When a bicycle is in motion, the force of friction exerted by the ground on the two wheels is always in forward direction

Statement 2: The frictional force acts only when the bodies are in contact

250

Statement 1: A table cloth can be pulled from a table without dislodging the dishes

Statement 2: To every action there is an equal and opposite reaction

251

Statement 1: A rocket in flight is a system of varying mass.

Statement 2: The rocket fuel is being consumed continuously.

252

Statement 1: Aeroplanes always fly at low altitudes

Statement 2: According to Newton's third law of motion, for every action there is an equal and opposite reaction

253

Statement 1: A body subjected to three concurrent forces cannot be in equilibrium

Statement 2: If large number of concurrent forces acting on the same point, then the point will be in equilibrium, if sum of all the forces is equal to zero

254

Statement 1: Use of ball bearings between two moving parts of machine is a common practice.

Statement 2: Ball bearings reduce vibrations and provide good stability.

255

Statement 1: A cyclist always bends inward while negotiating a curve

Statement 2: By bending, cyclist lowers his centre of gravity

256

Statement 1: The acceleration of a body down a rough inclined plane is greater than the acceleration due to gravity

Statement 2: The body is able to slide on a inclined plane only when its acceleration is greater than acceleration due to gravity

257

Statement 1: A reference frame attached to the earth is an inertial frame of reference

Statement 2: Newton's laws can be applied in this frame of reference

258

Statement 1: When ball of a mass m hits normally a wall with a velocity v and rebounds with same Velocity v, impulse imparted to the ball is $2mv$.

Statement 2: Impulse= change in linear momentum.

259

Statement 1: Linear momentum of a body changes even when it is moving uniformly in a circle

Statement 2: Force required to move a body uniformly along a straight line is zero

260

Statement 1: A player lowers his hands while catching a cricket ball and suffers less reaction force

Statement 2: The time of catch increases when cricketer lowers its hand while catching a ball

261

Statement 1: The maximum speed with which a vehicle can go round a level curve of diameter 20 m without skidding is $\sqrt{10}\ \text{ms}^{-1}$, given $\mu = 0.1$

Statement 2: It follows from $v \leq \sqrt{\mu r g}$

262

Statement 1: A string can never remain horizontal, when loaded at the middle, however large the tension may be

Statement 2: For horizontal spring, angle with vertical, $\theta = 90° \Rightarrow T = \frac{W}{2\cos\theta} = \frac{W}{2\cos 90°} = \infty$

263

Statement 1: The greater the rate of the change in the momentum vector, the greater the force applied

Statement 2: Newton's second law is $\vec{F} = \frac{d\vec{p}}{dt}$

264

Statement 1: The driver of a moving car sees a wall in front of him. To avoid collision, he should apply brakes rather than taking a turn way from the wall

Statement 2: Friction force is needed to stop the car or taking a turn on a horizontal road

265

Statement 1: In high jump, it hurts less when an athlete lands on a heap of sand

Statement 2: Because of greater distance and hence greater time over which the motion of an athlete is stopped, the athlete experience less force when lands on heap of sand

266

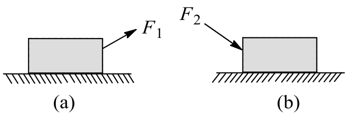
Statement 1: Friction is a self adjusting force

Statement 2: Friction does not depend upon mass of the body

267

Statement 1: Pulling (figure a) is easier than pushing (figure b) on a rough surface

Statement 2: Normal reaction is less in pulling than in pushing



268

Statement 1: A particle is found to be at rest when seen from a frame S_1 and moving with a constant velocity when seen from another frameS_2. We can say both the frames are inertial

Statement 2: All frames moving uniformly with respect to an internal frame are themselves internal

269

Statement 1: Newton's third law applies is applicable only when bodies are in motion

Statement 2: Newton's third law applies to all types of forces, $e.g.$ gravitational, electric or magnetic forces etc.

270

Statement 1: When the lift moves with uniform velocity the man in the lift will feel weightlessness

Statement 2: In downward accelerated motion of lift, apparent weight of a body decreases

271

Statement 1: A bullet is fired from a rifle. If the rifle recoils freely, the kinetic energy of the rifle is more than that of the bullet

Statement 2: In the case of rifle bullet system the law of conservation of momentum violates

272

Statement 1: Mass is a measure of inertia of the body in linear motion

Statement 2: Greater the mass, greater is the force required to change its state of rest or of uniform motion

273

Statement 1: Two bodies of masses M and $m(M > m)$ are allowed to fall from the same height if the air resistance for each be the same then both the bodies will reach the earth simultaneously

Statement 2: For same air resistance, acceleration of both the bodies will be same

274

Statement 1: Force is required to move a body uniformly along a circle

Statement 2: When the motion is uniform, acceleration is zero

275

Statement 1: It is not possible to drive a car on a slippery road

Statement 2: Friction always opposes motion

276

Statement 1: The velocity of a body at the bottom of an inclined plane of given height is more when it slides down the plane, compared to, when it rolling down the same plane

Statement 2: In rolling down a body acquires both, kinetic energy of translation and rotation

277

Statement 1: The slope of momentum versus time curve give us the acceleration

Statement 2: Acceleration is given by the rate of change of momentum

278

Statement 1: The value of dynamic friction is less than the limiting friction

Statement 2: Once the motion has started, the inertia of rest has been overcome

279

Statement 1: Frictional heat generated by the moving ski is the chief factor which promotes sliding in skiing while waxing the ski makes skiing more easy

Statement 2: Due to friction energy dissipates in the form of heat as a result it melts the snow below it. Wax is water repellent

280

Statement 1: Two particles are moving towards each other due to mutual gravitational attraction. The momentum of each particle will increase

Statement 2: Rate of change of momentum depends upon F_{ext}

281

Statement 1: A man in a closed cabin falling freely does not experience gravity

Statement 2: Inertial and gravitational mass have equivalence

282

Statement 1: A reference frame attached to earth is an inertial frame of reference

Statement 2: The reference frame which has zero acceleration is called a non inertial frame of reference

283

Statement 1: Friction is a self adjusting force

Statement 2: The magnitude of static friction is equal to the applied force and its direction is opposite to that of the applied force

284

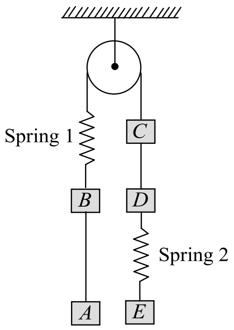
Statement 1: Moment of inertia is same as inertia

Statement 2: Moment of inertia of a body represents rotational inertia of the body

Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns I** have to be matched with Statements (p, q, r, s) in **columns II**.

285. The system shown below is initially in equilibrium. Masses of the blocks A, B, C, D, and E are, respectively, 3 kg, 3 kg, 2 kg, 2 kg and 2 kg, Match the conditions in Column I with the effect in Column II

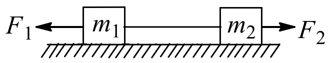
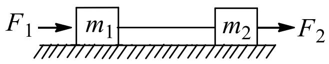
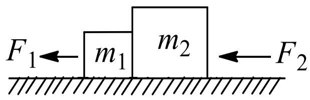
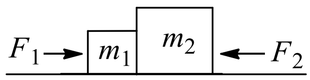


Column-I	Column- II
(A) After spring 2 is cut, tension is string AB	(p) Increases
(B) After spring 2 is cut, tension in string CD	(q) Decreases
(C) After string between C and pulley is cut, tension in string AB	(r) Remain constant
(D) After string between C and pulley is cut, tension in string CD	(s) Zero

CODES :

	A	**B**	**C**	**D**
a)	c	b	b,d	b
b)	b	b,d	b	c
c)	b,d	b	c	b
d)	b	c	b	b,d

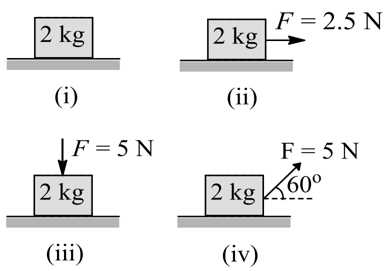
286. Column I gives four different situations involving two blocks of mass m_1 and m_2 placed in different ways on smooth horizontal surface as shown. In each of the situations, horizontal forces F_1 and F_2 are applied or blocks of mass m_1 andm_2, respectively and also $m_2F_1 < m_1F_2$. Match the statements in Column I with corresponding results in Column II

Column-I	Column- II
(A)  Both the block are connected by the massless inelastic string. The magnitude of tension in the string is	(p) $\frac{m_1m_2}{m_1+m_2}\left(\frac{F_1}{m_1}-\frac{F_2}{m_2}\right)$
(B)  Both the blocks are connected by the massless inelastic string. The magnitude of tension in the string is	(q) $\frac{m_1m_2}{m_1+m_2}\left(\frac{F_1}{m_1}+\frac{F_2}{m_2}\right)$
(C)  The magnitude of normal reaction between the blocks is	(r) $\frac{m_1m_2}{m_1+m_2}\left(\frac{F_2}{m_2}-\frac{F_1}{m_1}\right)$
(D)  The magnitude of normal reaction between the blocks is	(s) $m_1m_2\left(\frac{F_1+F_2}{m_1+m_2}\right)$

CODES :

	A	B	C	D
a)	c	b	c	b
b)	b	c	a	c
c)	c	b	a	b
d)	b	c	b	c

287. Coefficient of friction between the block and the surface in each of the given figures is 0.4. Match Column I with that of column II

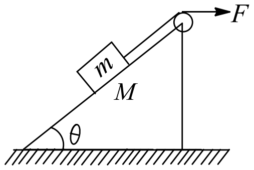


Column-I	Column- II
(A) Force of friction is zero in	(p) Fig i.
(B) Force of friction is 2.5 N in	(q) Fig ii.
(C) Acceleration of the block is zero in	(r) Fig iii.
(D) Normal force is not equal to 2g in	(s) Fig iv.

CODES :

	A	B	C	D
a)	A,b,c,d	c,d	a,c	b,d
b)	c,d	a,c	b,d	a,b,c,d
c)	a,c	b,d	a,b,c,d	c,d
d)	b,d	a,b,c,d	c,d	a,c

288. There is no friction anywhere in the system shown in figure. The pulley is light. The wedge is free to move on a frictionless surface. A horizontal force F is applied on the system in such a way that m does not slide on M or both move together with some common acceleration. Given $M > \sqrt{2}$ m



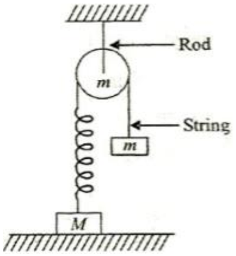
Match the entries of Column I with that of Column II

	Column-I		Column- II
(A)	Pseudo force acting on m as seen from the frame of M is	(p)	Equal to $\frac{mF}{m+M}$
(B)	Pseudo force acting on M as seen from the frame of m is	(q)	Greater than $\frac{mF}{m+M}$
(C)	Normal force (for $\theta = 45°$) between m and M is	(r)	Less than $mg\sin\theta$
(D)	Normal force between ground and M is	(s)	Greater than $mg\sin\theta$

CODES :

	A	B	C	D
a)	A,c	b,c	b,c	b,d
b)	b,c	b,c	b,d	a,c
c)	b,c	b,d	a,c	b,c
d)	b,d	a,c	b,c	b,c

289. In the figure shown, a block of mass m is released from rest when spring was in its natural length. The pulley also has mass m but it is friction less. Suppose the value of m is such that finally it is just able to lift the block M up after releasing it



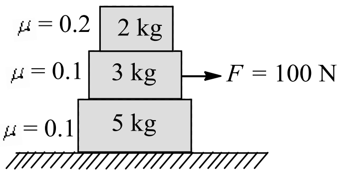
	Column-I		Column- II
(A)	Weight of 'm' required to just lift 'M'	(p)	$3\frac{M}{2}g$

(B)	Tension in the rod, when 'm' is in equilibrium	(q)	Mg
(C)	Normal force acting on M when m is in equilibrium	(r)	$\frac{M}{2}g$
(D)	Tension in the string when displacement of m is maximum possible	(s)	$2\ mg$

CODES :

	A	B	C	D
a)	a	b	c	d
b)	b,a	c	d	a
c)	c	c	c	b,d
d)	a,c	b	c,d	a,b

290. For the situation shown in figure in Column I, the statements regarding friction forces are mentioned, while in Column II some information related to friction forces are given
Match the entries of Column I with the entries of Column II



	Column-I		Column- II
(A)	Total friction force on 3 kg block is	(p)	Towards right
(B)	Total friction force on 5 kg block is	(q)	Towards left
(C)	Friction force on 2 kg block due to 3 kg block is	(r)	Zero
(D)	Friction force on 3 kg block due to 5 kg block is	(s)	Non-zero

CODES :

	A	B	C	D
a)	c	a,d	b,d	b,d
b)	a,d	b,d	b,d	c
c)	b,d	b,d	c	a,d
d)	b,d	c	a,d	b,d

291. Column I describes the motion of the object and one or more of the entries of Column II may be the cause of motions described in Column I. Match the entries of Column I with the entries of column II

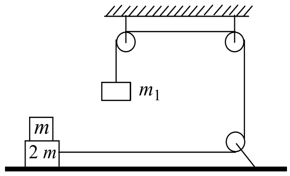
	Column-I		Column- II
(A)	An object is moving towards east	(p)	Net force acting on the object must be towards east
(B)	An object is moving towards east with constant acceleration	(q)	At least one force must act towards east

(C)	An object is moving towards east with varying acceleration	(r)	No forces may act towards east
(D)	An object is moving towards east with constant velocity	(s)	No force may act on the object

CODES :

	A	B	C	D
a)	A,c	a,c	c,d	c,d
b)	c,d	a,c	a,c	c,d
c)	a,c	c,d	c,d	a,c
d)	c,d	c,d	a,c	a,c

292. Coefficient of friction between the masses 2 m and m is 0.5. All other surface are frictionless and pulleys are massless. Column I gives the different values of m_1 and Column II gives the possible acceleration of 2 m and$m$. Match the columns



Column-I		Column- II	
(A)	$m_1 = 2m$	(p)	Accelerations of 2 m and m are same
(B)	$m_1 = 3\,m$	(q)	Accelerations of 2 m and m are different
(C)	$m_1 = 4\,m$	(r)	Acceleration of 2 m is greater than m
(D)	$m_1 = 6\,m$	(s)	Acceleration of m is less than 0.6 g

CODES :

	A	B	C	D
a)	A,d	a,d	b,c,d	b,c,d
b)	a,d	b,c,d	b,c,d	a,d
c)	b,c,d	b,c,d	a,d	a,d
d)	b,c,d	a,d	a,d	b,c,d

293. A block is attached to an unstretched vertical spring and released from rest. As a result of this block comes down due to its weight, stops momentarily, and then bounces back. Finally the block starts oscillating up and down

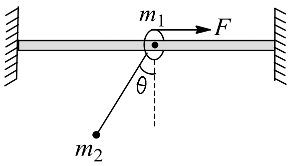
During oscillations, match Column I with Column II:

Column-I		Column- II	
(A)	When the block is at its maximum downward displacement position (may be known as extreme position)	(p)	Acceleration is in upward direction
(B)	When the block is at its equilibrium position	(q)	Acceleration is in downward is in downward direction
(C)	When the block is somewhere between equilibrium position and downward extreme position	(r)	Acceleration is zero
(D)	When the block is above equilibrium position but below the initial unstretched position	(s)	Velocity may be in upward or in downward direction

CODES :

	A	B	C	D
a)	C,d	a,d	b,d	a
b)	a	c,d	a,d	b,d
c)	a,d	b,d	a	c,d
d)	b,d	a	c,d	a,d

294. A horizontal force F pulls a ring of mass m_1 such that θ remains constant with time. The ring is constrained to move along a smooth rigid horizontal wire. A bob of mass m_2 hangs from m_1 by an inextensible light string. Then match the entries of Column I with that of Column II

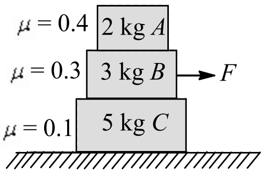


Column-I		Column- II	
(A)	F	(p)	$(m_1 + m_2)g$
(B)	Force acting on m_2 is	(q)	$m_2 g \sec\theta$
(C)	Tension in the string is	(r)	$m_2 \frac{F}{m_1 + m_2}$
(D)	Force acting on m_1 by the wire is	(s)	$(m_1 + m_2)g \tan\theta$

CODES :

	A	B	C	D
a)	d	c	b	a
b)	c	b	a	d
c)	b	a	d	c
d)	a	d	c	b

295. For the situation shown in the figure below, match the entries of Column I with the entries of Column II

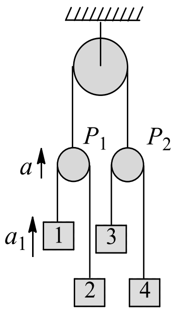


Column-I		Column- II	
(A)	If $F = 12$ N, then	(p)	There is relative motion between A and B
(B)	If $F = 15$ N, then	(q)	There is relative motion between B and C
(C)	If $F = 25$ N, then	(r)	There is relative motion between C and the ground
(D)	If $F = 40$ N, then	(s)	Relative motion is not there at any of the surface

CODES :

	A	**B**	**C**	**D**
a)	B,c	a,b,c	c	c
b)	a,b,c	c	c	b,c
c)	c	c	b,c	a,b,c
d)	c	b,c	a,b,c	c

296. In the system shown in figure, masses of the blocks are such that when the system is released, acceleration of pulley P_1 is a upwards and acceleration of block 1 is a_1 upwards. It is found that acceleration of block 3 is same as that of 1 both in magnitude and direction



Given that$a_1 > a > \frac{a_1}{2}$. Match the following

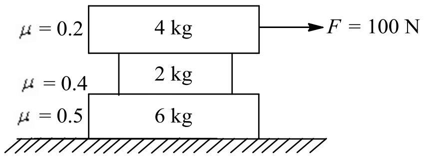
Column-I		Column- II	
(A)	Acceleration of 2	(p)	$2a + a_1$
(B)	Acceleration of 4	(q)	$2a - a_1$
(C)	Acceleration of 2 w.r.t. 3	(r)	Upwards
(D)	Acceleration of 2 w.r.t. 4	(s)	Downwards

CODES :

	A	**B**	**C**	**D**
a)	A,d	d	c	b,c
b)	b,c	a,d	d	c

c)	d	c	b,c	a,d
d)	c	b,c	a,d	d

297. For the situation shown in figure, in Column I, the statements regarding friction forces are mentioned, while in Column II some information related to friction forces are given



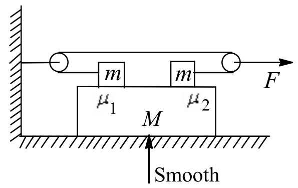
Match the entries of Column I with the entries of Column II

	Column-I		Column- II
(A)	Total friction force on 4 kg block is	(p)	Towards right
(B)	Total friction force on 2 kg block is	(q)	Towards left
(C)	Friction force on 6 kg block due to 2 kg block is	(r)	Zero
(D)	Total Friction force on 6 kg block is	(s)	Non-zero

CODES :

	A	**B**	**C**	**D**
a)	A,c	a,c	a	d
b)	c,d	a	b,c	a,d
c)	b,d	c	a,d	c
d)	a,c	a	c	d

298. For the figure shown, both the pulley are massless and frictionless. A force F (of any possible magnitude) is applied in horizontal direction. There is no friction between M and ground m_1 and m_2 are the coefficients of friction as shown between the blocks. Column I gives the different relations between m_1 andm_2, and Column II is regarding the motion of$M$. Match the columns:



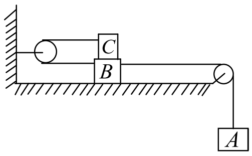
	Column-I		Column- II
(A)	If $\mu_1 = \mu_2 = 0$	(p)	May accelerate towards right
(B)	If $\mu_1 = \mu_2 \neq 0$	(q)	May accelerate towards right
(C)	If $\mu_1 > \mu_2$	(r)	Does not accelerate
(D)	If $\mu_1 < \mu_2$	(s)	May or may not accelerate

CODES :

	A	**B**	**C**	**D**

a)	A,b	c,d	c,d	d
b)	d,c	a,c	c	a
c)	a,d	b,d	a,	b
d)	c	c	b,d	a,d

299. When the system shown in figure is released, A accelerates downwards



	Column-I		**Column- II**
(A)	Acceleration of B	(p)	Towards left
(B)	Acceleration of C w.r.t B	(q)	Towards right
(C)	Acceleration of A w.r.t. C	(r)	At some angle θ with horizontal $(0 < \theta < 90°)$
(D)	Acceleration of B w.r.t. A	(s)	At some angle θ with vertical $(0 < \theta < 90°)$

CODES :

	A	**B**	**C**	**D**
a)	A,b	c	d	a
b)	b	a	c,d	c,d
c)	a,b	c	a,d	a
d)	c,d	a	c	b

Linked Comprehension Type

This section contain(s) 52 paragraph(s) and based upon each paragraph, multiple choice questions have to be answered. Each question has atleast 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 300 to -300

A body of mass 10 kg is lying on a rough horizontal surface. The coefficient of friction between the body and horizontal surface is 0.577. When the horizontal surface is inclined gradually, the body just begins to slide at a certain angle α. This is called angle of repose. When angle of inclination is increased further, the body slides down with some acceleration

300. The minimum force required just to slide the block on the horizontal surface is
a) 57.7 N b) 100 N c) 100 kg d) 57.7 kg

Paragraph for Question Nos. 301 to - 301

A force that acts on a body for a very short time is called impulsive force. Impulse measures the effect of the force. It is the product of force and time for which the force acts. Impulse is measured by the change in momentum of the body. For a given change in momentum, $F_{\text{avg}} \times t =$ constant. By increasing the tie (t) of impact, we can reduce the average force F_{av}

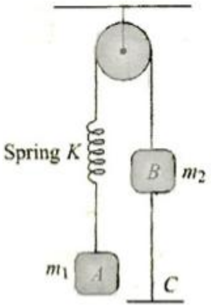
Read the above passage carefully and answer the following question ($g = 10\ ms^{-2}$)

301. If the impact lasts for 0.1s, force exerted by the impinging ball on the ground is

a) 45.2 N　　b) 45.2 kg-wt　　c) 42.5 N　　d) 42.5 kg-wt

Paragraph for Question Nos. 302 to - 302

In the system shown in the figure, $m_1 > m_2$. System is held at rest by threadBC. Now thread BC is burnt. Answer the following:



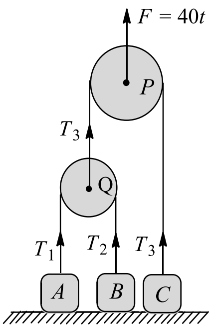
302. Before burning the thread, what are the tension in spring and threadBC, respectively?

a) m_1g, m_2g　　b) $m_1g, m_1g - m_2g$　　c) m_2g, m_1g　　d) $m_1g, m_1g + m_2g$

Paragraph for Question Nos. 303 to - 303

For problems-4-6

Three blocks$A$, B, and C having masses 1 kg, 2 kg, and 3 kg, respectively, are arranged as shown in figure. The pulleys P and Q are light and frictionless. All the blocks are resting on a horizontal floor and the pulleys are held such that strings remain just taut. At moment$t = 0$, a force $F = 40t$ N starts acting on pulley P along vertically upward direction as shown in the figure. Take $g = 10\ ms^{-2}$



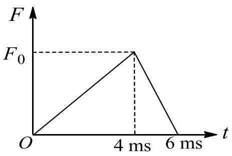
303. Regarding the times when blocks lose contact with ground, which is correct?

a) A loses contact at $t = 2$ s　　b) C loses contact at $t = 1.5$ s

c) A and B lose contact at the same time　　d) All three blocks lose contact at the same time

Paragraph for Question Nos. 304 to - 304

A ball of mass 200 gm is thrown with a speed 20 ms^{-1}. The ball strikes a bat and rebounds along the same line at a speed 40 ms^{-1}. Variation of the interaction force, as long s the ball remains in contact with the bat, is as shown in the figure

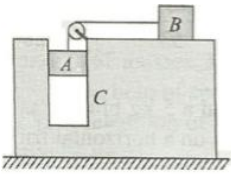


304. Maximum force F_0 exerted by the hat on the ball is

a) 4000 N b) 5000 N c) 3000 N d) 2500 N

Paragraph for Question Nos. 305 to - 305

In the system shown in the figure, $m_A = 4$ m, $m_B = 3$ m, and $m_c = 8$ m. friction is absent everywhere. String is inextensible and light. If the system is released from rest, then

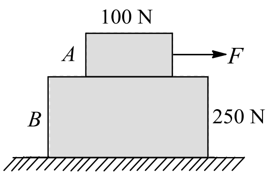


305. The tension in the string is

a) 1.5 mg b) 5.8 mg c) 4.7 mg d) 3.2 mg

Paragraph for Question Nos. 306 to - 306

Block B rests on a smooth surface. The coefficient of static friction between A and B is$\mu = 0.4$. When $F = 30$ N, then

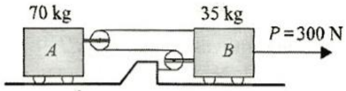


306. Acceleration of upper block is

a) 3/2 ms^{-2} b) 6/7 ms^{-2} c) 4/3 ms^{-2} d) 3/7 ms^{-2}

Paragraph for Question Nos. 307 to - 307

Study the following diagram and answer the following questions accordingly. Neglect all friction and the masses of the pulleys

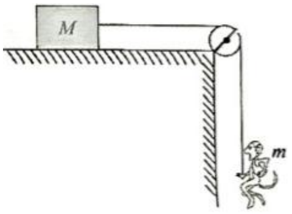


307. What is the tension in the string?

a) $\frac{700}{11}$ N b) $\frac{450}{11}$ N c) $\frac{500}{11}$ N d) $\frac{900}{11}$ N

Paragraph for Question Nos. 308 to - 308

A monkey of mass m clings to a rope slung over a fixed pulley. The opposite end of the rope is tried to a weight of mass M lying on a horizontal table. The coefficient of friction between the weight and the table isμ. Find the acceleration of weight and the tension of the rope for two cases



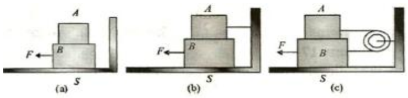
The monkey moves downwards with respect to the rope with an acceleration b

308. The acceleration of weight is

a) $\frac{2m(g+b)-\mu Mg}{M+2m}$n b) $\frac{m(g+b)-\mu Mg}{2(M+m)}$ c) $\frac{m(g+b)-3\mu Mg}{M+3m}$ d) $\frac{m(g-b)-\mu Mg}{M+m}$

Paragraph for Question Nos. 309 to - 309

Block A weights 4 N and block B weights 8 N. The coefficient of kinetic friction is 0.25 for all surfaces. Find the force F to slide B at constant speed when

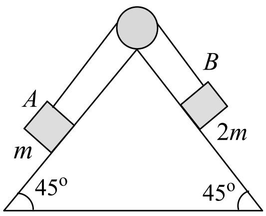


309. A rests on B and moves with it (figure a)

a) 2 N b) 3 N c) 4 N d) 5 N

Paragraph for Question Nos. 310 to - 310

Block A of mass m and block B of mass $2m$ are placed on a fixed triangular wedge by means of a massless inextensible string and a frictionless pulley as shown in the figure. The wedge in inclined at 45° to the horizontal on both sides. The coefficient of friction between block A and the wedge is $2/3$ and that between block B and the wedge is $1/3$. If the system of A and B is released from rest, find the following

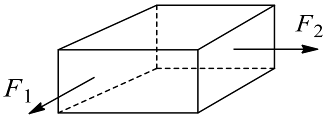


310. Acceleration of A is

a) $\frac{g}{3\sqrt{2}}$ b) Zero c) $\frac{g}{\sqrt{7}}$ d) $\frac{g}{2\sqrt{3}}$

Paragraph for Question Nos. 311 to - 311

A block of mass 10 kg is kept on a rough floor. Coefficient of friction between floor and block are $\mu_s = 0.4$ and$\mu_k = 0.3$. forces $F_1 = 5$ N and $F_2 = 4$ N are applied on the block as shown in the figure

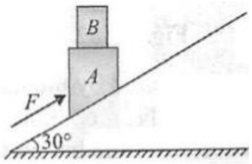


311. Determine the magnitude to friction force

a) $\sqrt{31}$ N b) $\sqrt{26}$ N c) $\sqrt{41}$ N d) $\sqrt{36}$ N

Paragraph for Question Nos. 312 to - 312

Block A has mass 40 kg and B has mass 15 kg and F is 500 N parallel to smooth inclined plane. The system is moving together

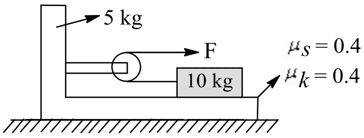


312. The acceleration of the system is

a) $\frac{45}{11}\text{ms}^{-2}$ b) $\frac{23}{11}\text{ms}^{-2}$ c) $\frac{13}{7}\text{ms}^{-2}$ d) $\frac{8}{3}\text{ms}^{-2}$

Paragraph for Question Nos. 313 to - 313

A 10 kg block rests on a 5 kg bracket as shown in the figure. The 5 kg bracket rests on a horizontal frictionless surface. The coefficients of friction between the 10 kg block and the bracket on which in rests are $\mu_s = 0.40$ and $\mu_s = 0.30$

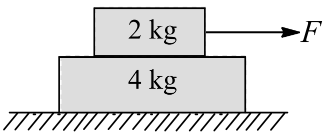


313. The maximum force F that can be applied if the 10 kg block is not to slide on the bracket is

a) 32 N b) 24 N c) 18 N d) 48 N

Paragraph for Question Nos. 314 to - 314

A sufficiently long plank of mass 4 kg is placed on a smooth horizontal surface. A small block of mass 2 kg is placed over the plank and is being acted upon by a time-varying horizontal force$F = (0.5\ t)$, where F is in newton and t is in seconds as shown in the figure. The coefficient of friction between the plank and the block is given as$\mu_a = \mu_k = \mu$. At ti9me $t = 12$ s, the relative slipping between the plank and the block is just likely to occur

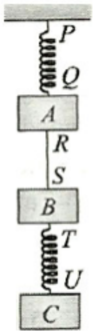


314. The coefficient of friction μ is equal to

a) 0.10 b) 0.15 c) 0.20 d) 0.30

Paragraph for Question Nos. 315 to - 315

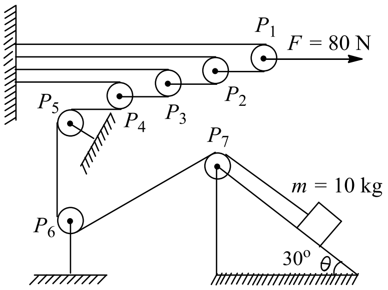
Three blocks$A$, B, and C of masses3 M, $2M$, and M are suspended vertically with the help of springsPQ, andTU, and a string RSas shown. If acceleration of blocks A, B, and C are a_1, a_2, and a_3 , respectively, then



315. The value of acceleration a_3 at the moment spring PQ is cut is
   a) g, downward
   b) g, upwards
   c) More than g, downwards
   d) Zero

Paragraph for Question Nos. 316 to - 316

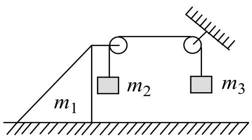
In the figure, all the pulleys and strings are massless and all the surfaces are frictionless. A small block of mass m is placed on fixed wedge (take $\mathrm{g} = 10\ \mathrm{ms}^{-2}$)



316. The tension in the string attached to m is
   a) 40 N
   b) 10 N
   c) 20 N
   d) 5 N

Paragraph for Question Nos. 317 to - 317

In the shown arrangement, both pulleys and the string are massless and all the surfaces are frictionless

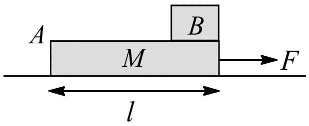


Given $m_1 = 1$ kg, $m_2 = 2$ kg, $m_3 = 3$ kg

317. Find the tension in the string
   a) $\frac{120}{7}$ N
   b) $\frac{240}{7}$ N
   c) $\frac{130}{7}$ N
   d) None of these

Paragraph for Question Nos. 318 to - 318

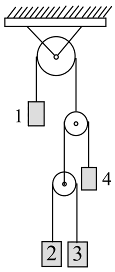
A plank A of mass M rests on a smooth horizontal surface over which it can move without friction. A cube B of mass m lies on the plank at one edge. The coefficient of friction between the plank and the cube isμ. The size of cube is very small in comparison to the plank



318. At what force F applied to the plank in the horizontal direction will the cube begin to slide towards the other end of the plank?
a) $F > \mu(m + M)$g b) $F > 0.5\mu(m + M)$g c) $F = 0.5\mu(m + M)$g d) $F = \mu(m + M)$g

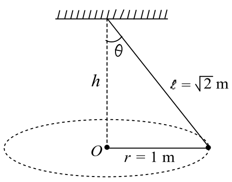
Paragraph for Question Nos. 319 to - 319

In the arrangement shown in the figure, all pulleys are smooth and massless. When the system is released from the rest, acceleration of blocks 2 and 3 relative to 1 are 1 ms^{-2} downwards and 5 ms^{-2} downwards, respectively. Acceleration of block 3 relative to 4 is zero



319. Find the absolute acceleration of block 1
a) 2 ms^{-2} upwards b) 1 ms^{-2} downwards c) 3 ms^{-2} upwards d) 1.5 ms^{-2} downwards

Paragraph for Question Nos. 320 to - 320



A sphere of mass 500 g is attached to a string of length $\sqrt{2}$ m, whose other end is fixed to a ceiling. The sphere is made to describe a circle of radius 1 m in a horizontal plane

320. Find the period of revolution for the sphere
a) $\pi\sqrt{10}$ s b) $\pi\sqrt{5}$ s c) $2\pi\sqrt{10}$ s d) $\pi\sqrt{5}$ s

Paragraph for Question Nos. 321 to - 321

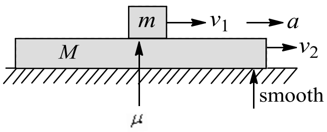
A ball of mass m is suspended from a rope of length$L$. It describes a horizontal circle of radius r with speed$v$. The rope makes and angle θ with the vertical

321. Find the tension in the rope

a) $\sqrt{(mg)^2+\left(\frac{mv^2}{2r}\right)^2}$ b) $\sqrt{(mg)^2-\left(\frac{mv^2}{r}\right)^2}$ c) $\sqrt{(mg)^2-\left(\frac{mv^2}{2r}\right)^2}$ d) $\sqrt{(mg)^2+\left(\frac{mv^2}{r}\right)^2}$

Paragraph for Question Nos. 322 to - 322

A small block of mass m is placed over a long plank of mass$M$. Coefficient of friction between them isμ. Ground is smooth. At $t=0, m$ is given a velocity v_1 and M a velocity $v_2(>v_1)$ as shown. After this M is maintained at constant acceleration $a(<\mu g)$



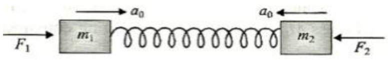
Initially there will be some relative motion between the block and the plank, but after some time relative motion will cease and velocities of both will become same

322. Find the time t_0 when velocities of both block and plank becomes same

a) $\frac{v_2-v_1}{\mu g+a}$ b) $\frac{v_2+v_1}{\mu g-a}$ c) $\frac{v_2-v_1}{\mu g-a}$ d) $\frac{v_2+v_1}{\mu g+a}$

Paragraph for Question Nos. 323 to - 323

Two blocks of masses m_1 and m_2 are connected with a light spring of force constant k and the whole system is kept on a frictionless horizontal surface. The masses are applied forces F_1 and F_2 as shown. At any time, the blocks have same acceleration a_0 but in opposite directions. Now answer the following

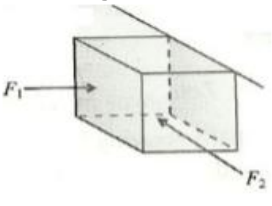


323. The value of a_0 is

a) $\frac{F_1-F_2}{m_1+m_2}$ b) $\frac{F_1-F_2}{m_1-m_2}$ c) $\frac{F_1+F_2}{m_1-m_2}$ d) $\frac{F_1+F_2}{m_1+m_2}$

Paragraph for Question Nos. 324 to - 324

A block of mass 4 kg is pressed against a rough wall by two perpendicular horizontal forces F_1 and F_2 as shown in the figure. Coefficient of static friction between the block and wall is 0.6 and that of kinetic is 0.5



324. For $F_1=300$ N and $F_2=100$ N, find the direction and magnitude of friction force acting on the block

a) 180 N, vertically upwards

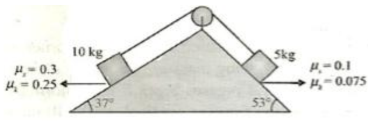
b) 40 N vertically upwards

c) 107.7 N making an angle of $\tan^{-1}\left(\frac{2}{5}\right)$ with the horizontal in the upward direction

d) 91.6 N, making an angle of $\tan^{-1}\left(\frac{2}{5}\right)$ with the horizontal in the upward direction

Paragraph for Question Nos. 325 to - 325

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 $g = 10\ ms^{-2}, \sin 37° = \frac{3}{5}$)



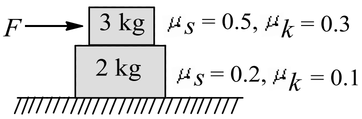
325. If the system is released from rest, then the acceleration of the system is

a) $\frac{7}{15}\ ms^{-2}$ b) Zero c) $\frac{47}{15}\ ms^{-2}$ d) $\frac{2.25}{15}\ ms^{-2}$

Paragraph for Question Nos. 326 to - 326

A system of two blocks is placed on a rough horizontal surface as shown in the figure below. The coefficient of static and kinetic friction at two surfaces are shown. A force F is horizontally applied on the upper block as shown

Let f_1, f_2 represent the frictional forces between upper and lower surfaces of contact, respectively, and a_1, a_2 represent the acceleration of 3 kg an d2 kg block, respectively



326. If F is gradually increasing force then which of the following statement (s) would be true?

a) For a particular value of $F(< F_0)$ there is no motion at any of the contact surface

b) The value of F_0 is 10 N

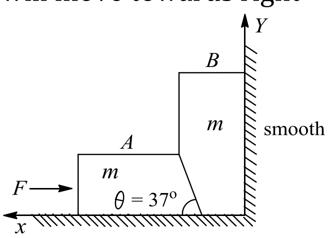
c) As F increase beyond F_0, f_1 increases and continues to increase until it acquires its limiting value

d) All of the above

Paragraph for Question Nos. 327 to - 327

Two smooth blocks are placed at a smooth corner as shown. Both the blocks are having mass$m$. We apply a force F on the small block$m$. Block A prsses block B in the normal direction, due to which passing force on vertical wall will increase, and pressing force on the horizontal wall decreases, as we increases $F(\theta = 37°$ with horizontal)

As soon as the pressing force on the horizontal wall by block B becomes zero, it will lose contact with ground. If the value4 of F further increase, block B will accelerate in the upward direction and simultaneously block A will move towards right

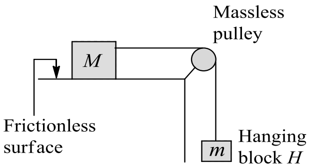


327. What is minimum value of F to lift block B from ground?

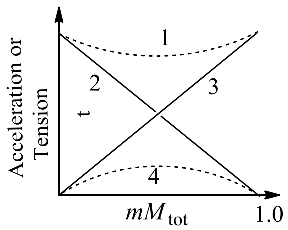
a) $\frac{25}{12}mg$ b) $\frac{5}{3}mg$ c) $\frac{3}{4}mg$ d) $\frac{4}{3}mg$

Paragraph for Question Nos. 328 to - 328

Two containers of sand are arranged like the block as shown. The containers alone have negligible mass; the sand in them has a total mass M_{tot}; the sand in the hanging container H has mass m



To measure the magnitude a of the acceleration of the system, a larger number of experiments carried out where m varies from experiment to experiment but M_{tot} does not; that is sand is shifted between the containers before each trial

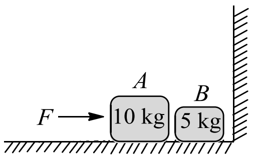


328. Which of the curves in graph correctly gives the acceleration magnitude as a function of the ratio m/M_{tot} (vertical axis is for acceleration)

a) 1 b) 2 c) 3 d) 4

Paragraph for Question Nos. 329 to - 329

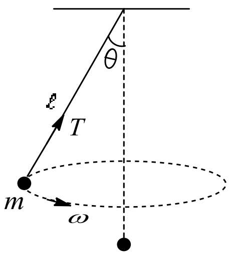
Two bodies A and B of masses 10 kg and 5 kg are placed very slightly separated as shown in the figure. The coefficient of friction between the floor and the blocks are as$\mu_a = 0.4$. Block A is pushed by an external force$F$. The value of F can be changed. When the welding between block A and ground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



329. If $F = 20$ N, with how much force does block A press block$B$?

a) 10 N b) 20 N c) 30 N d) Zero

Paragraph for Question Nos. 330 to - 330



A string of length ℓ is fixed at one end and carries a mass m at the other end. The string makes $2/\pi$ rps around a vertical axis throughout the fixed end so that the mass moves in horizontal circle

330. What is the tension in string?
   a) $m\ell$ b) $16m\ell$ c) $4m\ell$ d) $2m\ell$

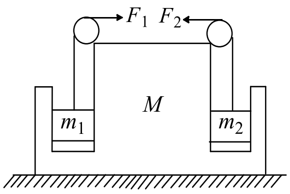
Paragraph for Question Nos. 331 to - 331

A time-varying force $F = 6t - 2t^2$ N, at $t = 0$ stats acting on a body of mass 2 kg initially at rest, where t is in second. The force is withdrawn just at the instant when the body comes to rest again. We can see that at $t = 0$, the force $F = 0$. Now answer the following:

331. Find the duration for which the force acts on the body
   a) 2 s b) 3 s c) 3.5 s d) 4.5 s

Paragraph for Question Nos. 332 to - 332

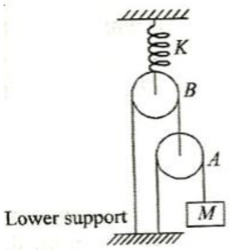
For the system shown in the figure, there is no friction anywhere. Masses m_1 and m_2 can move up or down in the slots cut in mass$M$. Two non-zero horizontal forces F_1 and F_2 are applied as shown. The pulleys are massless and frictionless. Given $m_1 \neq m_2$



332. According to the above passage, which is correct?
   a) It is not possible for the entire system to be in equilibrium
   b) For some values of F_1 and F_2, it is possible that entire system is in equilibrium
   c) It is possible that F_1 and F_2 are applied in such a way that m_1 and m_2 remain in equilibrium but M does not
   d) None of the above

Paragraph for Question Nos. 333 to - 333

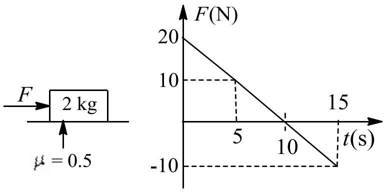
A mass M is suspended as shown in the figure. The system is in equilibrium. Assume pulleys to be massless. K is the force constant of the spring



333. The extension produced in the spring is given by
a) 4 Mg/K b) Mg/K c) 2 Mg/K d) 3 Mg/K

Paragraph for Question Nos. 334 to - 334

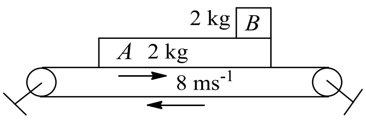
On a stationary block of mass 2 kg, a horizontal, a horizontal force f starts acting at $t = 0$ whose variation with time is shown in the adjoining diagram. Coefficient of friction between the block and ground is 0.5. Now answer the following questions:



334. Find the time when acceleration of the block is zero
a) At 5 s only
b) At 10 s only
c) Both at 5 s and 10 s
d) At a time after $t = 10$ s only

Paragraph for Question Nos. 335 to - 335

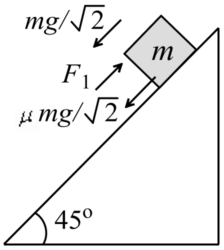
A long conveyer belt moves with a constant velocity of 8 ms^{-1}. Two blocks A and B each of mass 2 kg are placed gently on the belt with B on A. Initial velocity of both blocks is zero. Coefficient of friction between A and belt is 0.1. There is no friction between A and$B$. Length of A is 4 m



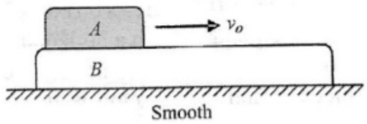
335. Find the time when B falls off$A$. Initially B is on right end of$A$. Ignore the dimensions of B
a) 1 s b) 3 s c) 2 s d) 4 s

Integer Answer Type

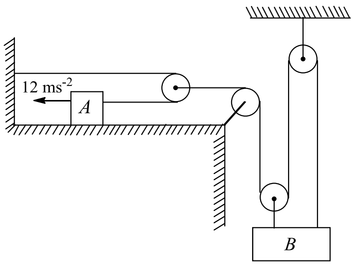
336. A block is moving on an inclined plane making an angle 45° with the horizontal and the coefficient of friction is μ. The force required to just push it up the inclined plane is 3 times the force required to just prevent it from sliding down. If we define $N = 10\mu$, then N is



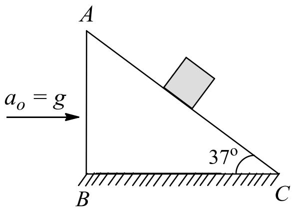
337. You are designing an elevator for a hospital. The force exerted on a passenger by the floor of the elevator is not to exceed 1.60 times the passenger's weight. The elevator accelerates upward with constant acceleration for a distance of 3.0 m and then starts to slow down. What is the maximum speed (inms^{-1}) of the elevator?
338. A block A of mass m is palced 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 0.4. Block A is given a velocity v_0 towards right. Find acceleration (in ms^{-2}) of B relative to A



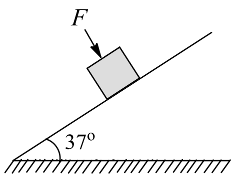
339. Block A is given an acceleration 12 ms^{-2} towards left as shown in figures. Assuming the block B always remains horizontal, find the acceleration (in ms^{-2}) of B



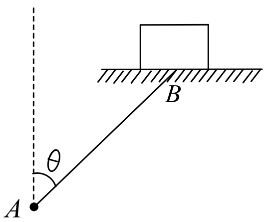
340. A block is placed on an inclined plane moving towards right horizontally with an acceleration$a_0 = g$. The length of the plane $AC = 1$ m. Friction is absent everywhere. Find the time taken (in second) by the block to reach from C to A



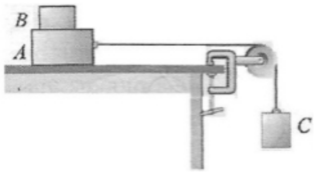
341. A block of mass $m = 2$ kg is resting on a rough inclined plane of inclination 30° as shown in figure. The coefficient of friction between the block and the plane is$\mu = 0.5$. What minimum force F (in newton) should be applied perpendicular to the plane, so that block does not slip on the plane?



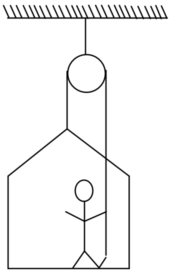
342. A rod AB of length 2 m is hinged at point A and its other end B is attached to a platform on which a block of mass m is kept. Rod rotates about point A maintaining angle $\theta = 30°$ with the vertical in such a way that platform remains horizontal and revolves on the horizontal circular path. If the coefficient of static friction between the block and platform is $\mu = 0.1$, then fin d the maximum angular velocity in rad s^{-1} of rod so that block does not slip on the platform ($g = 10\ ms^{-2}$)



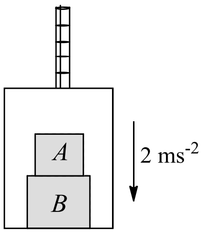
343. Block$B$, of mass $m_B = 0.5$ kg, rests on block$A$, with mass $m_A = 1.5$ kg, which in turn is on a horizontal tabletop (as shown in figure). The coefficient of kinetic friction between block A an the tabletop is $\mu_k = 0.4$ and the coefficient of static friction between block A and block B is$\mu_s = 0.6$. A light string attached to block C is suspended from the other end of the string. What is the largest mass m_C (in kg) that block C can have so0 that blocks A and B still slide together when the system is released from rest?



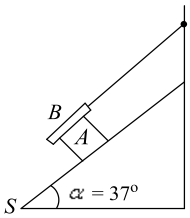
344. Figure represents a painter in a crate which hangs alongside a building. When the painter of mass 100 kg pulls the rope, the force exerted by him on the floor of the crate is 450 N, If the crate weights 25 kg, find the acceleration (in ms^{-2}) of the painter



345. The elevator shown in figure is descending with an acceleration of2 ms^{-2}. The mass of the block $A = 0.5$ kg. Find the force (in Newton) exerted by the block A on the block B



346. A block$A$, of weight$W$, slides down an inclined plane S of slope 37° at a constant velocity, while the plank$B$, also of weight$w$, rests on top of A. The plank B is attached by a cord to the top of the plane. The coefficient of kinetic friction μ is the same between the surfaces A and B and between S and A. Determine the value of $1/\mu$



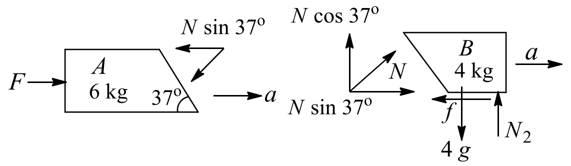
: ANSWER KEY :

1)	c	2)	b	3)	b	4)	c	5)	a,b,c	6)	a,d	7)	b,c	8)	
5)	c	6)	d	7)	d	8)	a		b,c						
9)	b	10)	b	11)	b	12)	d	9)	a,d	10)	a,b,c,d	11)	a,c	12)	a
13)	a	14)	c	15)	d	16)	c	13)	c	14)	b,d	15)	a,b,d	16)	d
17)	c	18)	c	19)	c	20)	a	17)	a	18)	b,c,d	19)	b	20)	c
21)	d	22)	d	23)	c	24)	b	21)	a	22)	a,b,c,d	23)	a,c,d	24)	
25)	c	26)	c	27)	c	28)	c		a,b,c						
29)	d	30)	b	31)	c	32)	a	25)	a,b,c	26)	a,c	27)	d	28)	c
33)	a	34)	b	35)	c	36)	c	29)	a,c	30)	a,b,c	31)	a	32)	
37)	d	38)	a	39)	a	40)	b		a,c						
41)	d	42)	c	43)	d	44)	b	33)	b	34)	c,d	35)	b	36)	
45)	d	46)	c	47)	c	48)	a		a,b,d						
49)	a	50)	b	51)	d	52)	c	37)	a,c	38)	b,d	39)	b	40)	
53)	b	54)	d	55)	c	56)	d		a,d						
57)	a	58)	b	59)	b	60)	c	41)	b,c,d	42)	a,c	43)	a	44)	d
61)	b	62)	b	63)	a	64)	d	45)	b,d	46)	a,c	1)	c	2)	c
65)	c	66)	b	67)	b	68)	c		3)	c	4)	c			
69)	a	70)	d	71)	d	72)	b	5)	d	6)	b	7)	b	8)	a
73)	d	74)	a	75)	a	76)	a	9)	a	10)	a	11)	c	12)	e
77)	b	78)	c	79)	c	80)	a	13)	c	14)	a	15)	d	16)	c
81)	d	82)	b	83)	a	84)	c	17)	a	18)	c	19)	d	20)	d
85)	b	86)	a	87)	b	88)	a	21)	c	22)	e	23)	b	24)	a
89)	b	90)	d	91)	b	92)	c	25)	a	26)	e	27)	c	28)	c
93)	a	94)	b	95)	d	96)	a	29)	d	30)	d	31)	a	32)	b
97)	c	98)	d	99)	c	100)	a	33)	a	34)	a	35)	a	36)	a
101)	b	102)	d	103)	d	104)	b	37)	b	38)	a	39)	d	40)	d
105)	c	106)	a	107)	a	108)	d	41)	b	42)	e	43)	e	44)	d
109)	b	110)	c	111)	c	112)	b	45)	a	46)	d	47)	b	48)	b
113)	c	114)	b	115)	c	116)	b	49)	a	50)	d	51)	a	52)	a
117)	b	118)	b	119)	b	120)	b	53)	a	54)	a	55)	d	56)	d
121)	b	122)	b	123)	b	124)	a	57)	a	1)	a	2)	d	3)	c
125)	b	126)	b	127)	c	128)	b		4)	a					
129)	a	130)	c	131)	d	132)	d	5)	c	6)	d	7)	b	8)	a
133)	d	134)	d	135)	a	136)	a	9)	b	10)	a	11)	c	12)	b
137)	c	138)	b	139)	c	140)	d	13)	c	14)	d	15)	b	1)	d
141)	a	142)	a	143)	a	144)	c		2)	c	3)	b	4)	b	
145)	c	146)	a	147)	d	148)	c	5)	a	6)	a	7)	b	8)	d
149)	c	150)	d	151)	a	152)	a	9)	d	10)	b	11)	b	12)	c
153)	a	154)	d	155)	a	156)	a	13)	a	14)	b	15)	c	16)	d
157)	b	158)	a	159)	d	160)	d	17)	d	18)	a	19)	d	20)	a
161)	d	162)	b	163)	a	164)	b	21)	c	22)	d	23)	c	24)	b
165)	d	166)	a	167)	b	168)	b	25)	c	26)	b	27)	d	28)	c
169)	b	170)	c	171)	c	172)	d	29)	a	30)	d	31)	b	32)	d
173)	d	174)	c	175)	c	176)	a	33)	a	34)	a	35)	c	36)	c
177)	a	178)	d	179)	c	180)	a	1)	5	2)	6	3)	6	4)	2
181)	c	1)	a,b,c	2)	a,b	3)		5)	1	6)	8	7)	1	8)	5
	b,c	4)	a,b,c					9)	2	10)	4	11)	4		

: HINTS AND SOLUTIONS :

1 **(c)**

$F - N\sin 37° = 6a \;\Rightarrow\; F - \frac{3N}{5} = 6a$ (i)



$N_2 = 4g - N\cos 37° = 40 - \frac{4N}{5}$ (ii)

$N\sin 37° - f = 4a$ (iii)

From (i) and (iii): $F - f = 10a$

$\Rightarrow F - mN_2 = 10a$ (iv)

$\Rightarrow\; F - m\left[40 - \frac{4N}{5}\right] = 10a$ (v)

Put the value of N from (i) in (v) and also put the value of m to get $a = \frac{5F-60}{42}$

Now to start motion: $a > 0 \;\Rightarrow F > 12$ N

So the minimum force F to just start the motion is 12 N

Now maximum F will be when N_2 just becomes zero

Then from (ii): $N = 50$ N

From (i) and (ii), we get $F = 75$ N (by putting $N_2 = 0$

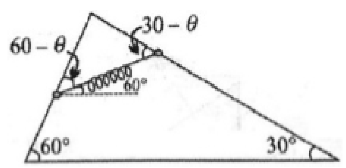
If we apply $F > 75$ N, then B will start sliding up on A, but we do not want this

3 **(b)**

For constant acceleration if initial velocity makes an angle with acceleration, then path will be parabolic

4 **(c)**

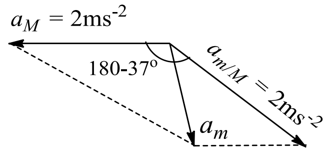
In equilibrium, if θ is the required angle, Cylinder A: $mg\sin 60° = kx\cos(60° - \theta)$



Cylinder B: $mg\sin 30° = kx\cos(30° + \theta) = kx\sin(60° - \theta)$ on solving $\theta = 30°$

5 **(c)**

If acceleration of M is 2 ms^{-2}, then acceleration of m e.r.t. M will be 2 ms^{-2}



Acceleration of m w.r.t. ground

$a_m = \sqrt{2^2 + 2^2 + 2\times 2\times 2\cos(180 - 37°)}$

$= \sqrt{8/5}\ \text{ms}^{-2}$

6 **(d)**

Here the force applied should be such that friction force acting on the upper block of m should not be more than the limiting friction$(= \mu_1 mg)$. Let the system moves with acceleration$a$. Then for whole system,

$F - \mu_2(M + m)\text{g} = (M + m)a$ (i)

For block of mass m,

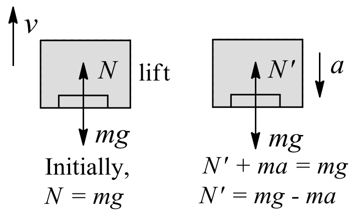
$f_1 = ma$ or $\mu_1 mg = ma$ or $a = \mu_1\text{g}$ (ii)

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

$F = (M + m)\text{g}(\mu_1 + \mu_2)$

7 **(d)**

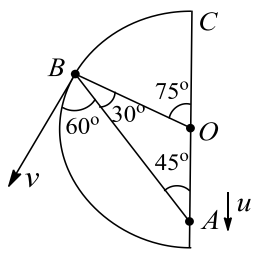
The reading of the spring scale is the normal reaction between man and spring scale figure



As the reading is decreasing, it means normal reaction is decreasing. Firstly, the lift must be moving upwards with constant velocity and decelerated to rest

8 **(a)**

As in figure $u\cos 45° = v$



cos 60°

or $v = \sqrt{2}u$

9 **(b)**

Since m is in equilibrium w.r.t. observer, acceleration of m should also be a_2. So net friction force (as there is no other horizontal force on m) acting on m should be mass ×acceleration $= ma_2$

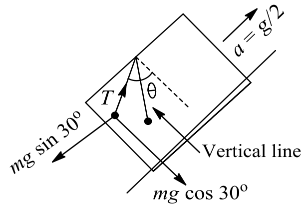
10 **(b)**

$T\sin\theta - mg\sin 30° = ma$

$\Rightarrow\; T\sin\theta = mg\sin 30° + mg/2$ (i)

$T\cos\theta = mg\cos 30°$ (ii)

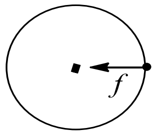
Dividing (i) by (ii), we get



$\tan\theta = \dfrac{2}{\sqrt{3}}$

11 **(b)**

$f_1 = \mu m g$, friction will provide the necessary centripetal force $f = m\omega^2 r$



$f \le f_\ell \;\Rightarrow\; m\omega^2 r \le \mu m g$

$\Rightarrow \mu \ge \dfrac{\omega^{2r}}{g} = \dfrac{2^2 \times 50/100}{10} \Rightarrow \mu \ge 0.2$

12 **(d)**

Let spring does not get elongated, then net pulling force on the system is $Mg + mg - mg$ or simplyMg. Total mass being pulled is$M + 2m$. Hence, acceleration of the system is

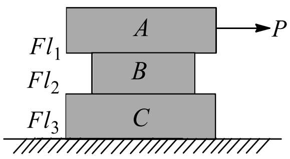
$a = \dfrac{Mg}{M + 2m}$

Now since$a < g$, there should be an upward force on M so that its acceleration becomes less than g. It means there is some tension developed in the string. Hence, for any value of M spring will be elongated

13 **(a)**

$f\ell_1 = \mu_1 m_A g = 0.3 \times 300 = 90$ N

$f\ell_2 = \mu_2(m_A + m_B)g = 0.2(300 + 100) = 80$ N



$\ell f_3 = \mu_3(m_A + m_B + m_C)g$

$= 0.1(300 + 100 + 200) = 60$ N

14 **(c)**

Let the tension in the rope be$T$. Let the acceleration of the man and chair to a upwards

For man: $T + 450 - 1000 = \frac{1000}{10} a$

or $T = 550 + 100a$ (1)

For chair: $T - 450 - 250 = \left(\frac{250}{10}\right) a$

or $T = 700 + 25a$ (ii)

From (i) and (ii), we get $a = 2\ \text{ms}^{-2}$

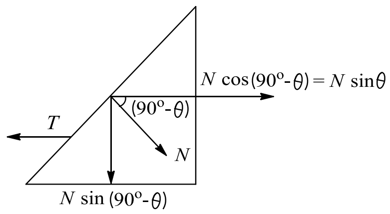
15 **(d)**

Force $= V\dfrac{dm}{dt}$

16 **(c)**

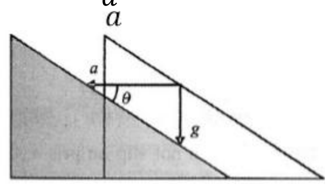
$T = N\sin\theta$ and $N = mg\cos\theta$

$T = mg\cos\theta\sin\theta = \dfrac{mg}{2}\sin 2\theta$



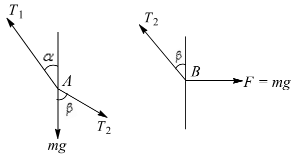
17 **(c)**

$\tan\theta = \dfrac{g}{a} \Rightarrow a = g\cot\theta$



18 **(c)**

From figure, $T_2\cos\theta = mg, T_2\sin\theta = mg$



$T_1\sin\alpha = mg\sqrt{2}\sin 45°$

$T_1\sin a = mg \Rightarrow \dfrac{\cos\alpha}{\sin\alpha} = \dfrac{2mg}{mg}$

$\tan\alpha = \dfrac{1}{2} \Rightarrow \cos\alpha = \dfrac{2}{\sqrt{5}}$

$T_1\dfrac{2}{\sqrt{5}} = 2\,mg \Rightarrow T_1 = mg\sqrt{5}$

$\dfrac{T_1}{T_2} = \dfrac{\sqrt{5}}{\sqrt{2}} \Rightarrow \sqrt{2}T_1 = \sqrt{5}\,T_2$

19 **(c)**

Acceleration of suitcase till the slipping continuous is

$a = \dfrac{f_{\max}}{m}$

$a = \dfrac{\mu m g}{m} = \mu g = 0.05 \times 10 = 5\ \text{ms}^{-2}$

Slipping will continue till its velocity also becomes $3\ \text{ms}^{-1}$

$\therefore v = u + at$

or $3 = 0 + 5t$ or $t = 0.6$ s

in this time, displacement of suitcase

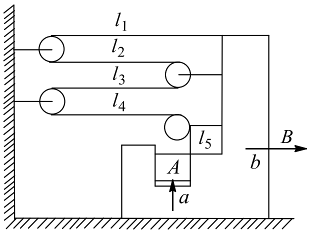
$s_1 = \frac{1}{2}at^2 = \frac{1}{2} \times 5 \times (0.6)^2 = 0.9$ m

and displacement of belt, $s_2 = vt = 3 \times 0.6 = 1.8$ m

Displacement of suitcase with respect to belt

$s_1 - s_2 = 0.9$ m. this displacement will be opposite to the direction of motion of belt

20 **(a)**



Acceleration of A in horizontal direction = the acceleration of $B = b$ rightwards

Acceleration of A in vertical direction =the acceleration of A with respect to b in upwards direction $= a = 4b$

Hence, net acceleration of $A = b\hat{\imath} + 4b\hat{\jmath}$

21 **(d)**

Speed $v = \sqrt{v_x^2 + v_y^2}$

Rate of change of speed

$$\frac{dv}{dt} = \frac{2v_x\frac{dv_x}{dt} + 2v_y\frac{dv_y}{dt}}{2\sqrt{v_x^2 + v_y^2}}$$

$$= \frac{v_x a_x + v_y a_y}{\sqrt{v_x^2 + v_y^2}}$$

22 **(d)**

Force $\mathbf{F} = \frac{\mathbf{dp}}{dt} = -k\, A\sin(kt)\,\hat{\mathbf{i}} - k\, A\cos(kt)\,\hat{\mathbf{j}}$

$\mathbf{p} = A\cos(kt)\,\hat{\mathbf{i}} - A\sin(kt)\,\hat{\mathbf{j}}$

Since, $\mathbf{F}\cdot\mathbf{p} = 0$

$\therefore$ Angle between $\mathbf{F}$ and $\mathbf{p}$ should be 90°

23 **(c)**

Given ($V = 10\text{ ms}^{-1}$)

After 2s: $V_x = \frac{V}{\sqrt{2}} - \frac{g}{\sqrt{2}}\times 2 \;\Rightarrow V_x = \frac{10}{\sqrt{2}} - \frac{10}{\sqrt{2}}\times 2$

$V_x = -\frac{10}{\sqrt{2}}\text{ms}^{-1}$and $V_y = -\frac{10}{\sqrt{2}}\text{ms}^{-1}$

$$V = \sqrt{\frac{100}{2} + \frac{100}{2}} = 10\sqrt{\frac{1}{2} + \frac{1}{2}} = 10\text{ ms}^{-1}$$

24 **(b)**

Frictional force $= \mu R = \mu(mg + Q\cos\theta)$ and horizontal push$= P - Q\sin\theta$

For equilibrium, we have

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

25 **(c)**

At any instant, velocity of two wedges would be of same magnitude but it opposite directions. This can be concluded from conservation of momentum or by symmetry

From constraint theory, $v_M = \frac{4}{3}v_m$

From energy conservation,

$$\frac{Mv_M^2}{2}\times 2 + \frac{mv_m^2}{2} - 0 = mgh \;\Rightarrow v_M = \sqrt{\frac{32\,mgh}{32M + 9m}}$$

So the velocity with which wedges recede away form each other is

$$2v_M = \sqrt{\frac{32mgh\times 4}{32M + 9m}}$$

26 **(c)**

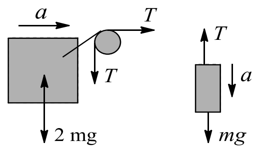
By virtual work method:

Acceleration of B w.r.t. A will be 10 ms^{-2} downward. Apart from this, B also has an acceleration 5 ms^{-1} in horizontal direction along with A, so net acceleration of B is

$\sqrt{10^2 + 5^2} = \sqrt{100 + 25} = \sqrt{125} = 5\sqrt{5}\text{ ms}^{-2}$

27 **(c)**

$T = 2ma$



$mg - T = ma$

$a = g/3$

28 **(c)**

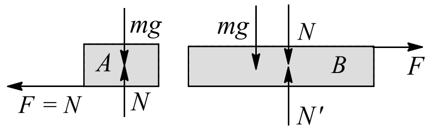
The minimum force required to just move a body will be$f_1 = \mu_s mg$. After the motion is started, the friction will becomes kinetic. So the force which is responsible for the increase in velocity of the block is

$F = (\mu_s - \mu_k)mg = (0.8 - 0.6)\times 4\times 10 = 8\text{ N}$

So, $a = \frac{F}{m} = \frac{8}{4} = 2\text{ ms}^{-2}$

29 **(d)**

Free-body diagram (figure)



Equations of motion:

$a_B = \frac{F}{M}$ (in $+x$ direction)

$a_A = \frac{F}{m}$ (in $-x$ direction)

Relative acceleration of A w.r.t. B:

$\vec{a}_{A.B} = \vec{a}_A - \vec{a}_B = -\frac{F}{m} - \frac{F}{M} = -F\left(\frac{m+M}{mM}\right)$

(along $-x$ direction)

Initial relative velocity of A w.r.t. B

$u_{A.B} = v_0$

Final relative velocity of A w.r.t. $B = 0$

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

$$0 = v_0^2 - 2\frac{F(m+M)}{mM}S \Rightarrow S = \frac{Mmv_0^2}{2F(m+M)}$$

30 **(b)**

Angular frequency of the system,

$$\omega = \sqrt{\frac{k}{m+m}} = \sqrt{\frac{k}{2m}}$$

Maximum acceleration of the system will be, $\omega^2 A$ or $\frac{kA}{2m}$. This acceleration to the lower block is provided by friction.

Hence, $f_{\max} = ma_{\max}$

$$= m\omega^2 A = m\left(\frac{k\,A}{2m}\right) = \frac{k\,A}{2}$$

31 **(c)**

Here friction force would be responsible to cause the acceleration of truck., here maximum friction force can be $f = \mu \times < \frac{Mg}{2}$ where $M \to$ mass of entire truck

This is the net force acting on tyre, so $Ma = \frac{\mu Mg}{2}$

$$\Rightarrow a = \frac{0.6 \times 10}{2} = 3 \text{ ms}^{-2}$$

32 **(a)**

The water jet striking the block at the rate of 1 kg s^{-1} at a speed of 5 ms^{-1} will exert a force on the block

$$F = v\frac{dm}{dt} = 5 \times 1 = 5 \text{ N}$$

Under the action of this force of 5 N, the block of mass 2 kg will move with an acceleration given by

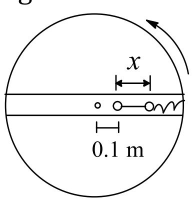
$$a = \frac{F}{m} = \frac{5}{2} = 2.5 \text{ ms}^{-2}$$

33 **(a)**

Minimum effort is required by pulling a block at the angle of friction

34 **(b)**

$K = 10^2 \text{N cm}^{-1} = 10^4 \text{Nm}^{-1}$. Let the ball move distance x away from the centre as shown in figure



$$kx = mw^2(0.1 + x)$$

$$\Rightarrow 10^4 x = \frac{90}{1000} \times (10^2)^2 \times (0.1 + x)$$

Solve to get $x \approx 10^{-2}$ m

35 **(c)**

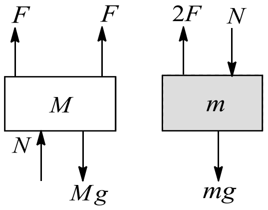
Distance travelled in t^{th} second is,

$$s_t = u + at - \frac{1}{2}a$$

Given, $u = 0$

$$\therefore \frac{s_n}{s_n + 1} = \frac{an - \frac{1}{2}a}{a(n+1) - \frac{1}{2}a} = \frac{2n-1}{2n+1x}$$

36 **(c)**



From figure,

$$2F + N - Mg = Ma$$

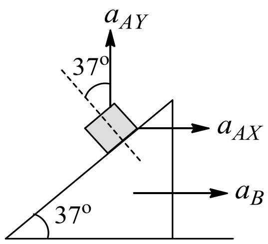
$$2F - mg - N = ma$$

$$4\,F - (M+m)g = (M+m)a$$

$$a = \frac{4F - (M+m)g}{M+m}$$

37 **(d)**

From constraint, the acceleration of both block and wedge should be same in a direction perpendicular to the inclined plane as shown in figure



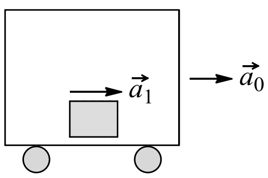
$(a_A)_\perp = (a_B)_\perp, a_{AX} = 15, a_{AY} = 15$

$a_{AX} \cos 53° - a_{AY} \cos 37° = a_B \cos 53°$

or $a_B = -5 \text{ ms}^{-1}$ or $\vec{a}_B = -5\hat{\imath}$

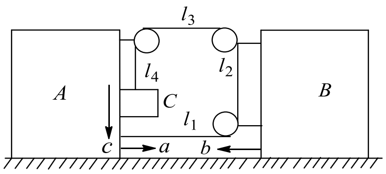
38 **(a)**

Let $\vec{a}_0$ be the acceleration of choosen non-inertial frame of reference w.r.t some inertial frame of reference and $\vec{a}_1$ be the acceleration of the object in non-inertial frame



For $\vec{a}_1$ to be non-zero, the net force acting on object (including pseudo force) must be non-zero

39 **(a)**



From length constraint $\ell_1 + \ell_2 + \ell_3 + \ell_4 = C$

$\ell_1'' + \ell_2'' + \ell_3'' + \ell_4'' = 0$

$(-a - b) + 0 + (-a - b) + c = 0$

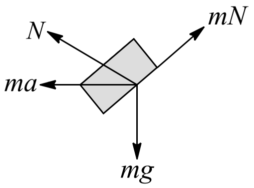
$c = 2a + 2b$

From wedge constraints, acceleration of C is right side is$a$. Acceleration of C w.r.t. ground

$= a\hat{\imath} - 2(a + b)\hat{\jmath}$

40 **(b)**

FBD of m in frame of wedge



$N = mg\cos\alpha - ma\sin\alpha$

Now $f = \mu N = ma\cos\alpha + mg\sin\alpha$

$$\mu = \frac{a\cos\alpha + \mathrm{g}\sin\alpha}{\mathrm{g}\cos\alpha - a\sin\alpha}$$

$$\mu = \frac{a + \mathrm{g}\tan\alpha}{\mathrm{g} - a\tan\alpha} = \frac{5}{12}$$

41 **(d)**

Let the tension in the strings AP_2 and P_2P_1 be$T$. Considering the force on pulley P_1, we get $T = W_1$. Further, let $\angle AP_1P_1 = 2\theta$

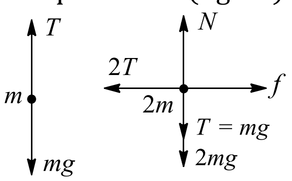
Resolving tensions in horizontal and vertical directions and considering the forces on pulley P_2, we get $2T\cos\theta = W_2$

or $2\,W_1\cos\theta = W_2$ or $\cos\theta = 1/2$

or $\theta = 60°$ So $\angle AP_2P_1 = 2\theta = 120°$

42 **(c)**

In equilibrium (figure)



$T = mg, N = 3\,mg$ and $f = 2T = 2\,mg$

In limiting case $f < f_{\max}$

$2mg < \mu N \Rightarrow 2mg \le 3\mu\,mg \Rightarrow \mu \ge \dfrac{2}{3}$

43 **(d)**

Time taken by the bullet and ball to strike the ground is

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 5}{10}} = 1\text{ s}$$

Let v_1 and v_2 are the velocities of ball and bullet after collision. Then applying

$x = vt$

We have, $20 = v_1 \times 1$

or $v_1 = 20$ m/s

$100 = v_2 \times 1$ or $v_2 = 100$ m/s

Now, from conservation of linear momentum before and after collision we have,

$0.01v = (0.2 \times 20) + (0.01 \times 100)$

On solving, we get

$v = 500$ m/s

44 **(b)**

Before cutting the string, the tension in string joining m_4 and the ground is $T = (m_1 + m_2 - m3{-}m4$g and the spring force in the spring joining m_3 and m_4 is $T + m_4$g. As the string is cut, the spring forces do not change instantly, so just after cutting the string the equilibrium of m_1, m_2 and m_3 would be maintained but m_4 accelerates in upward direction with acceleration given by

$$a = \frac{T + m_4\mathrm{g} - m_4\mathrm{g}}{m_4}$$

45 **(d)**

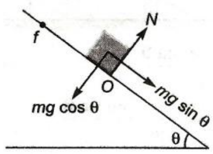
Condition of sliding is

$mg\sin\theta > \mu\,mg\cos\theta$

or $\tan\theta > \mu$

or $\tan\theta > \sqrt{3}$ ...(i)

condition of toppling is



Torque of $mg\sin\theta$ about $O >$ torque of $mg\cos\theta$ about.

$\therefore\quad (mg\sin\theta)\left(\dfrac{15}{2}\right) > (mg\cos\theta)\left(\dfrac{10}{2}\right)$

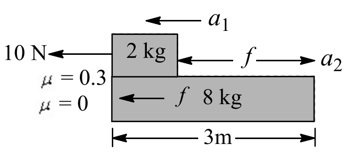
or $\tan\theta > \dfrac{2}{3}$ ....(ii)

With increase in value of θ, condition of sliding is satisfied first.

46 **(c)**

Friction between 2 kg and 8 kg blocks is kinetic in nature, so

$F = m \times 2\mathrm{g} = 0.3 \times 2 \times 10 = 6\mathrm{N}$



For 2 kg block, $10 - 6 = 2a_1$

For 8 kg block, $6 = 8a_2$

$\Rightarrow\ a_1 = 2\text{ ms}^{-2}, a_2 = \dfrac{3}{4}\text{ms}^{-2}$

Acceleration of 2 kg block relative to 8 kg block is

$a_{\text{ref}} = a_1 - a_2 = \frac{5}{4}\text{ms}^{-2}$

Using the equation of motion, $3 = \frac{1}{2} \times \frac{5}{4} r^2$

$t = 2.19$ s

47 **(c)**

From 0 to 2 s: at any time $t, F = 10\,t$

$\Rightarrow a = F/m = 10t/m$

$$\Rightarrow \int_0^v dv = \int_0^t \frac{10t}{m} dt \Rightarrow v = \frac{5t^2}{m}$$

Momentum: $P = mv = 5t^2$

At $t = 2$ s, $P = 5(2)^2 = 20$ kg ms^{-1}, $v = 20/m$

From 2 to 4 s; $F = 40 - 10\,t$

$$\int_{20/m}^{v} dv = \int_2^t \frac{40 - 10t}{m} dt \;\Rightarrow\; v$$

$$= \frac{1}{m}[40t - 40 - 5t^2]$$

$P = mv = 40t - 40 - 5t^2$

48 **(a)**

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

49 **(a)**

Initially under equilibrium of mass m

$T = mg$

Now, the string is cut. Therefore, $T = mg$ force is decreased on mass m upward and downwards on mass $2m$.

$\therefore\; a_m = \frac{mg}{m} = g \quad (downwards)$

$and\; a_{2m} = \frac{mg}{2m} = \frac{g}{2}\; (upwards)$

50 **(b)**

For the equilibrium of block of mass M_1:

Frictional force, f =tension in the string, T

Where $T = f = \mu(m + M_1)$g (i)

For the equilibrium of block of mass M_2:

$T = M_2$g (ii)

Form (i) and (ii), we get $\mu(m + M_1)g = M_2$g

$m = \frac{M_2}{\mu} - M_1$

51 **(d)**

If the blocks move together,

$a = \frac{F}{m_A + m_B} = \frac{10}{6} = \frac{5}{3}\text{ms}^{-1}$

f_B (frictional force on B)= $m_B a = \frac{m_B F}{m_A + m_B} = \frac{20}{3}$N

$f_{B\max} = \mu m_A$g $= 0.4 \times 2 \times 10 = 8$ N

As $f_{B\max} > f_B$, the blocks will not be separated and move together with common acceleration $5/3$ ms^{-2}

52 **(c)**

As sand particles are sliding down, the slope of the hill gets reduced. The sand particle stops coming down when component of gravity force alone hill is balanced by limiting friction force

$mg\sin\theta = \mu_s mg\cos\theta$

$\Rightarrow\; \theta = \tan^{-1}(\mu_s) \cong 37°$ where θ is the new slope angle of hill

53 **(b)**

Suppose F = upthrust due to buoyancy

Then while descending, we find

Mg $- F = Ma$ (i)

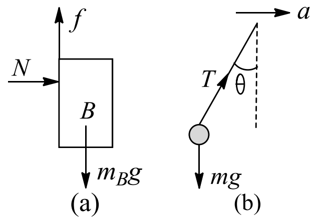
When ascending, we have

$F - (M - m)$g $= (M - m)a$ (ii)

Solving Eqs. (i) and (ii), we get $m = \left[\frac{2a}{a + \text{g}}\right] M$

54 **(d)**

In the free-body diagram of B (figure (a))



$N = m_B a$ (i)

$f = m_B$g

$\mu N = m_B$g (ii)

Form (i) and (ii), $a = \frac{\text{g}}{\mu} = 20$ ms^{-2}

FBD of bob:

$T\sin\theta = ma$ (iii)

$T\cos\theta = mg$ (iv)

From (iii) and (iv)

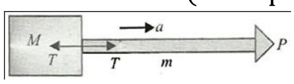
$\tan\theta = \frac{a}{\text{g}} \;\Rightarrow\; \theta = \tan^{-1}(2)$

55 **(c)**

Let a be the common acceleration of the system

Here $T = Ma$ (for block)

$P - T = Ma$ (for rope)



$P - Ma = ma$

or $P = (m + M)a$ or $a = P/(m + M)$

now $T = Ma = \frac{MP}{M+m}$

56 **(d)**

Maximum acceleration of B or C can be mg so that they do not slip with each other or on A

For the system of $(A + B + C)$

$T = 3\,ma = 3\,\mu\,mg$

For D:

Mg $- T = Ma$

$\Rightarrow M$g $- 3\mu\,mg = M\mu$g $\Rightarrow M = \frac{3\mu m}{1 - \mu}$

57 **(a)**

$v_2 \cos\alpha + v_1 \cos\alpha = v_1 \quad \Rightarrow \quad v_2 = v_1\left[\frac{2\sin^2(\alpha/2)}{\cos\alpha}\right]$

58 **(b)**

The cloth can be pulled out without dislodging the dishes from the table due to law of inertia, which is Newton's first law. While, the statement II is true, but it is Newton's third law.

59 **(b)**

Velocity of liquid through inclined limbs $= \frac{v}{2}$

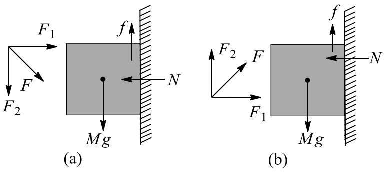
Rate of change of momentum of the liquid is

$\rho A v^2 + 2\left[\rho A\left(\frac{v}{2}\right)^2 \cos 60°\right] = \frac{5}{4}\rho A v^2$

60 **(c)**

As the eraser is at rest w.r.t. board, friction between two is static in nature

For figure (a) and (b), the friction force is same as that of gravity force as shown in figure



For (c), $f = F_2 + Mg > Mg$

For (d) $Mg - F_2 < Mg$ as angle by which arm is tilted is very small, so F_2 would be small

61 **(b)**

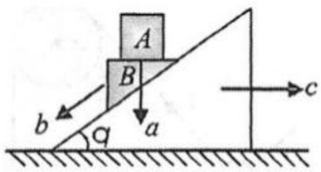
For A:

$5g - T = 5(2C)$

For C: $2T - 8g = 8C \quad \Rightarrow \quad C = \frac{8}{14} = \frac{5}{7}\ \text{ms}^{-2}$

62 **(b)**

1. Acceleration of block A downwards w.r.t. ground



2. Acceleration of block B w.r.t. inclined plane
3. Acceleration of block C w.r.t. ground right side. $\vec{b} + \vec{c}$ acceleration of B w.r.t. ground

Applying Newton's law on system along horizontal direction, we have

$mc + m(c - b\cos\theta) = 0 \quad$ (i)

Applying Newton's law on $(A + B)$ along the inclined plane,

$2mg\sin\theta = m(b - c\cos\theta) + ma\sin\theta$

$2g\sin\theta = b - c\cos\theta + a\sin\theta \quad$ (ii)

From wedge constraint between A and B,

$a = b\sin\theta \quad$ (iii)

From Eq. (i), (ii) and (iii), $b = \frac{4g\sin\theta}{1+3\sin^2\theta}$

63 **(a)**

For chain to move with constant speed, P needs to be equal to frictional force on the chain. As the length of chain on the rough surface increases. Hence, the friction force $f_k = \pi_k N$ increases

64 **(d)**

Let at any time, their velocities are v_1 and v_2, respectively, then $v_1 = v_2\cos\theta$

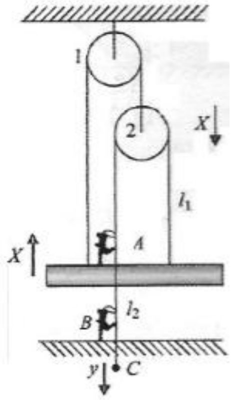
Differentiating: $a_1 = a_2\cos\theta - v_2\sin\theta\frac{d\theta}{dt}$

Hence, none of them is correct

[Note: Option (a) is correct initially, because initially $v_2 = 0$]

65 **(c)**

Let the plank move up by x, then pulley 2 will move down by x. Let the end of string C moves down by a distance y



Let the initial length of string passing over pulley

$2\,\ell_1 + \ell_2$ (i)

After displacement x and y mentioned above, the lengths becomes

$(\ell_1 - 2x) + (\ell_2 + y - x) \quad$ (ii)

Equating (i) and (ii), we get $y = 3x$

Length of string that slips through A is $y + x = 4x$

Length of string that slip[s through A is

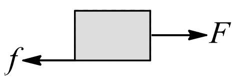
$y + x = 4x$ and the through B is $y = 3x$

Required ratio $\frac{4x}{3x} = \frac{4}{3}$

66 **(b)**

Horizontal acceleration of the system is

$a = \frac{F}{2m + m + 2m} = \frac{F}{2m}$



Let N be the normal reaction between B and C.

Free-body diagram of C gives

$N = 2ma = \frac{2}{5}F$

Now B will nor slide downwards if $\mu N \geq m_B g$

Or $\mu\left(\frac{2}{5}F\right) \geq mg \ \ or \ \ F \geq \frac{5}{2\mu}mg$

Or $F_{\min} = \frac{5}{2\mu} mg$

67 **(b)**

$$t_A = \sqrt{\frac{2s}{a_A}} \Rightarrow t_D = \sqrt{\frac{2s}{a_D}},\ t_A = \frac{1}{2} t_D$$

$$\sqrt{\frac{2s}{g\sin\theta + \mu g\cos\theta}} = \frac{1}{2}\sqrt{\frac{2s}{g\sin\theta - \mu g\cos\theta}}$$

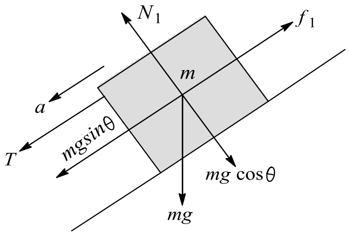
$4g\sin\theta - 4\mu g\cos\theta = g\sin\theta + \mu g\cos\theta$

$3g\sin\theta = 5\mu g\cos\theta$ or $\mu = \frac{3}{5}\tan\theta = \frac{3}{5}$

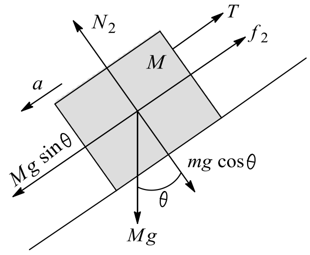
($\because\ \theta = 45°$)

68 **(c)**

$N_1 = mg\cos\theta$ and $f_1 = \mu\, mg\cos\theta$



$N_2 = Mg\cos\theta$ and $f_2 = \mu\, Mg\cos\theta$



Equation of motion are

$T - f_1 = mg\sin\theta = ma$ (i)

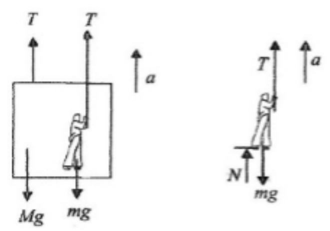
$Mg\sin\theta - T - f_2 = Ma$ (ii)

Solving Eqs. (i) and (ii), we get $T = 0$

69 **(a)**

$2T - (M+m)g = (M+m)a$ (i)

$T - mg + N = ma$ (ii)



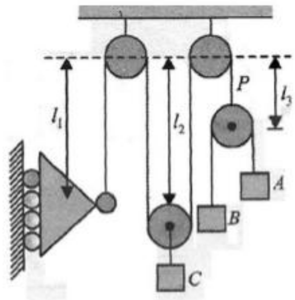
From (i) and (ii), we get

$$N = \left(\frac{m-M}{2}\right)(g + a) > 0$$

As $m > M$, if T increase, a increase and if a increase N increases

70 **(d)**

Using constraint theory



$\ell_1 + 2\ell_2 + \ell_3 = \text{constant}$

$\Rightarrow\ v_1 + 2v_2 + v_3 = 0$

Take downward as positive and upward as –ve

So $+12 + 2(-4) + v_3 = 0$

v_3 =velocity of pulley $P = -4\ \text{ms}^{-1}$

$= 4\text{ms}^{-1}$In upward direction

$\vec{v}_{AP} = -\vec{v}_{BP} \Rightarrow V_{AP} = -(v_B - v_P)$

$v_B = v_P - v_{AP} = -4 - (3) = -7\ \text{ms}^{-1}$

i.e., block B is moving up with speed 7 ms^{-1}

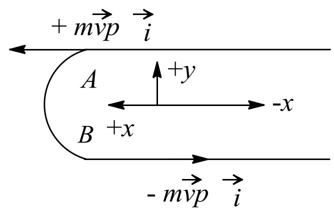
71 **(d)**

$\vec{v}_{B,\ell} = 4\ \text{ms}^{-1} \uparrow, \vec{V}_{B,\ell} = \vec{V}_B, g - \vec{V}_\ell, g$

$\Rightarrow 4\ \text{ms}^{-1} = \vec{V}_{Bg}, -2\ \text{ms}^{-1}; \vec{V}_{Bg},. = 6\ \text{ms}^{-1} \uparrow$

72 **(b)**

Choosing the positive $x - y$ axis as shown in the figure, the momentum of the bead at A is$\vec{p}_i = +m\vec{v}$. The momentum of the bead at B is $\vec{p}_f = -m\vec{v}$



Therefore, the magnitude of the change in momentum

Between A and B is $\Delta\vec{p} = \vec{p}_f - \vec{p}_i = -2m\vec{v}$

i.e., $\Delta p = 2\ mv$ along the positive x-axis

the time taken by the bead to reach from A to B is

$$\Delta t = \frac{\pi d/2}{v} = \frac{\pi d}{2v}$$

Therefore, the average force exerted by the bead on the wire is

$$F_{\text{av}} = \frac{\Delta p}{\Delta p} = \left(2mv/\frac{\pi d}{2v}\right) = \frac{4mv^2}{\pi d}$$

73 **(d)**

The acceleration of block-rope system is

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

Where M is the mass of block and m is the mass of rope

So the tension in the middle of the rope will be

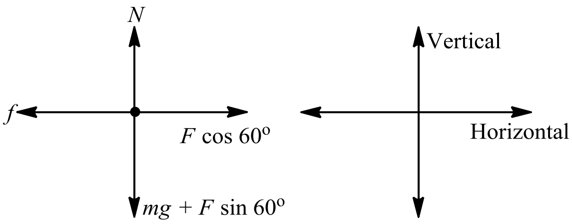
$$T = \{M + (m/2)\}a = \frac{M + (m/2)F}{M + m}$$

Given that $m = M/2$

$\therefore T = \left[\frac{M + (M/4)}{M + (M/2)}\right] F = \frac{5F}{6}$

74 **(a)**

Free body diagram (FBD) of the block (shown by a dot) is shown in figure.



For vertical equilibrium of the block,

$N = mg + F \sin 60° = \sqrt{3}\, g + \sqrt{3}\frac{F}{2}$ …. (i)

For no motion, force of friction

$f \geq F \cos 60°$

or °μ $N \geq F \cos 60°$

or $\frac{1}{2\sqrt{3}}\left(\sqrt{3}\, g + \frac{\sqrt{3}\, F}{2}\right) \geq \frac{F}{2}$

or $g \geq \frac{F}{2}$ or $F \leq 2\, g$ or 20 N

Therefore, maximum value of $F$is 20 N.

75 **(a)**

Applying Newton's law on system along horizontal direction, we have

$mc + m(c - b\cos\theta) = 0$ (i)

$c = \frac{b\cos\theta}{2}$

76 **(a)**

During downward motion:

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

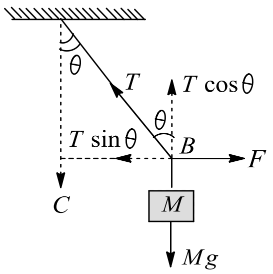
During upward motion:

$2F = mg\sin\theta + \mu mg\cos\theta$

Solving above two equations, we get $m = (\tan\theta)/3$

77 **(b)**

In figure, the point B is in equilibrium under the action of T, F and Mg



Here $T\sin\theta - F$ or $T = F/\sin\theta$

78 **(c)**

$a_1 = \frac{F - f}{m_1} = \frac{F - \mu m_1 g}{m_1} = 10 \text{ ms}^{-2}$

$a_2 = \frac{F - \mu m_2 g}{m_2} = 1 \text{ ms}^{-2}$

$\therefore s = \frac{1}{2} a_{\text{real}} t^2 = \frac{1}{2}[10 + 1]t^2 \Rightarrow t = 2\text{s}$

79 **(c)**

Due to acceleration in forward direction, vessel is in an accelerated frame therefore a Pseudo force will be exerted in backward direction. Therefore water will be displaced in backward direction

80 **(a)**

$x = 0$, till $mg\sin\theta < \mu mg\cos\theta$ and gradually x will increase. At angle $\theta > \tan^{-1}(\mu)$

$kx + \mu mg\cos\theta = mg\sin\theta$

or $x = \frac{mg\sin\theta - \mu\, mg\cos\theta}{k}$

Here k is the force constant of spring

81 **(d)**

From constraint relations we can see that the acceleration of block B in upward direction is

$a_B = \left(\frac{a_C + a_A}{2}\right)$ with proper sings

So $a_B = \left(\frac{3 - 12t}{2}\right) = 1.5 - 6t$

or $\frac{dv_B}{dt} = 1.5 - 6t$ or $\int_0^{v_B} dv_B = \int_0^1 (1.5 - 6t)\, dt$

or $v_B = 1.5t - 3t^2$ or $v_B = 0$ at $t = 1/2$ s

82 **(b)**

Retardation of train $= 20/4 = 5 \text{ ms}^{-2}$

It acts in the backward direction. Fictious force on suitcase= $5m$ Newton, wherer m is the mass of suitcase. In act6s in the forward direction. Due to this force, the suitcase has a tendency to slide forward. If suitcase is not to slide, then $5m =$ Newton, where m is the mass of suitcase. In acts in the forward direction. Due to this force, the suitcase has a tendency to slide forward. If suitcase is not to slide, then $5m =$ force f of friction

or $5m = m\, mg$ or $m = \frac{5}{10} = 0.5$

83 **(a)**

When

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

$f = \mu mg\cos\theta$ (upwards)

when $P = mg\sin\theta$

$f = 0$

and when $P = mg(\sin\theta + \mu\cos\theta)$

$f = \mu\, mg\cos\theta$ (downwards)

Hence, friction is first positive, then zero and then negative.

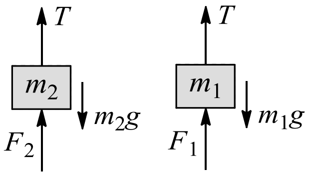
85 **(b)**

As the springs have natural length initially, if one spring is compressed, the other must be expanded. Hence, the compression will be negative

The free-body diagram of m_2 [figure]

$T + F_2 = 80$ N and $F_2 = 70 \times 0.5 = 35$ N

$\therefore \; T = 80 - 35 = 45$ N



FBD of m_1 (figure)

$T + F_1 = m_1 g$ or $F_1 = -25$ N

$\therefore \; X_1 = \frac{-25}{k_1} = \frac{-25}{50} = -0.5$ m

Therefore, compression in first spring is -0.5 m (negative sing indicates that it is extension)

86 **(a)**

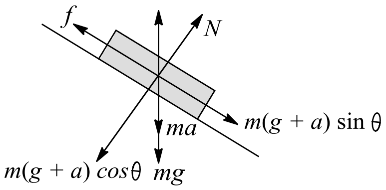
For upward acceleration of M_1:

$M_2 g \geq M_1 g \sin\theta + \mu M_1 g \cos\theta$

$\Rightarrow \; (M_2)_{\min} = M_1(\sin\theta + \mu\cos\theta)$

87 **(b)**

Figure, $F_c = \sqrt{f^2 + N^2} = m(g + a)$

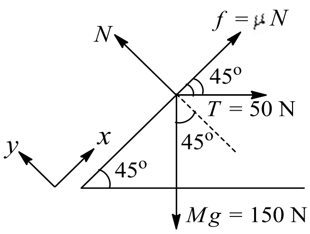


$f = m(g + a)\sin\theta$, $N = m\,(g + a)\cos\theta$

Net contact force: $F_C = \sqrt{f^2 + N^2} = m(g + a)$

88 **(a)**

The string is under tension, Hence there is limiting friction between the block and the plane figure



$\sum F_x = 0$

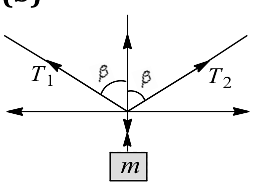
$\Rightarrow \; \mu N + 50\cos 45° = 150 \sin 45°$ (i)

$\sum F_y = 0$

$\Rightarrow \; N = 50\sin 45° + 150\cos 45°$ (ii)

Solving (i) and (ii), we get $m = 1/2$

89 **(b)**



$\tan\beta = \frac{12}{5} \quad \therefore \cos\beta = \frac{5}{13}$

$T_1\cos\beta + T_2\cos\beta = mg$ (i)

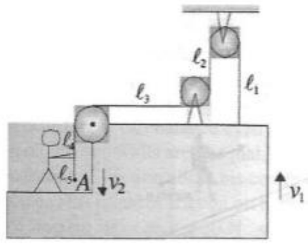
$T_1\sin\beta = T_2\sin\beta$ (ii)

$\therefore T_1 = T_2 = T$

$\therefore 2T\cos\beta = mg \; \Rightarrow \; T = \frac{mg}{2\cos\beta} \; \Rightarrow T = \frac{13}{10}mg$

90 **(d)**

Let v_1 be the velocity of block and v_2 be the velocity of end A of the string, w.r.t. man



$\frac{d\ell_5}{dt} = v_2 = 2\text{ ms}^{-1}$ (given) , $\frac{d\ell_1}{dt} = \frac{d\ell_2}{dt} = -v_1$

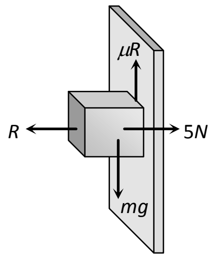
Now $\ell_1 + \ell_2 + \ell_3 + \ell_4 + \ell_5 =$constant

$\Rightarrow \frac{d\ell_1}{dt} + \frac{d\ell_2}{dt} + 0 + 0 + \frac{dls}{dt} = 0$

$\Rightarrow \; -v_1 - v_1 + v_2 = \; 0 \; \Rightarrow \; v_1 = \frac{v_2}{2} = \frac{2}{2} = 1\text{ ms}^{-1}$

91 **(b)**

Limiting friction $F_1 = \mu_s R = 0.5 \times (5) = 2.5\,N$



Since downward force is less than limiting friction therefore block is at rest so the static force of friction will work on it

$F_s =$ downward force $=$ Weight

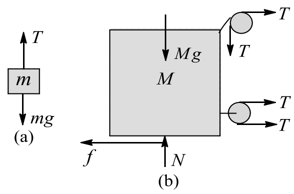
$= 0.1 \times 9.8 = 0.98\,N$

92 **(c)**

In the free-body diagram of m [figure (a)],

$T = mg$ (i)

[No friction will act between M and m



In the free-body diagram of M (figure (b))

$f = \mu_2 N = 3T$ (ii)

and $T + Mg = N$ (iii)

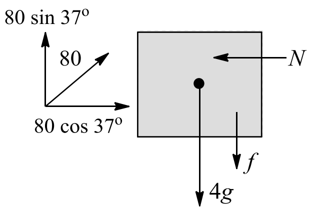
From Eq. (iii), $N = (m + M)g$

From Eq. (ii), $\mu_2(m + M)g = 3\,mg$

$$m = \frac{\mu_2 M}{(3-\mu_2)} = \frac{1/3 \times 8}{(3-1/3)} = 1\ kg$$

93 **(a)**

The FBD of the block is as shown in the figure



$N = 80 \cos 37° = 64$ N

So, $f_L = 0.2 \times 64 = 32$ N

As $4g < 80 \sin 37°$, friction force will act downwards. Net applied force in upward direction (excluding friction force) is

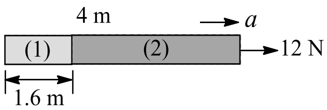
$80 \sin 37° - 40 = 48 - 40 = 8$ N

As F_{applied} in vertical direction is less than f_L, block won't move in vertical direction and value of static friction force is $f = 8$ N

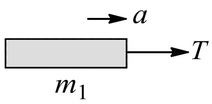
94 **(b)**

As in the figure, mass of the rope: $m = 4 \times 1.5 = 6$ kg

Acceleration: $a = 12/6 = 2\ \text{ms}^{-2}$



Mass of part 1 as in the figure 7.567 $m_1 = 1.6 \times 1.5 = 2.4$ kg



$T = m_1 a = 2.4 \times 2 = 4.87$ N

95 **(d)**

$$\vec{a} = \frac{\vec{F}}{m} = -10\hat{j}\ (\text{ms}^{-1})^2$$

Displacement in y-direction

$$y = ut + \frac{1}{2}at^2 \Rightarrow 0 = 4 \times t \times -\frac{1}{2} \times 10 \times t^2$$

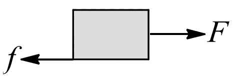
$$t = \frac{4}{5}s \Rightarrow x = 4t = 4 \times \frac{4}{5} = 3.2 \text{ m}$$

96 **(a)**

$f_l = mMg$. If motion does not start, then

$f = F = F_0 t$

Motion will start when $f = f_1$



$$\Rightarrow F_0 T = \mu M g \Rightarrow T = \frac{\mu M g}{F_0}$$

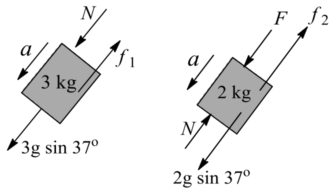
97 **(c)**

The free-body diagrams of two blocks are shown in figure. Under the assumption that blocks are moving together,

$F + 2g \sin 37° + 3\,g \sin 37° - f_1 - f_2 = 5a$

Where $f_1 = \mu \times 3g \cos 37°$

And $f_2 = \mu \times 2g \cos 37°$

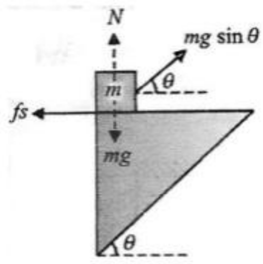


$$\Rightarrow a = \frac{46}{5}\text{ms}^{-2}$$

For 3 kg block, $N + 3g \sin 37° - f_1 = 3a \Rightarrow N = 12$ N

98 **(d)**

As the block does not slip on prism, the combined acceleration of the prism is $a = g \sin \theta$



$mg \sin \theta$ is the pseudo force on m

$N + mg \sin \theta + \sin \theta = mg$ or $N = mg \cos^2 \theta$

And for no slipping, $mg \sin \theta \cos \theta \geq \mu N$

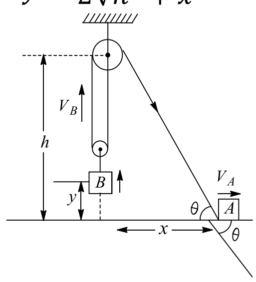
$mg \sin \theta \cos \theta \leq \mu mg \cos^2 \theta$ or $\mu \geq \tan \theta$

99 **(c)**

From figure $L = 2h - 2y + \sqrt{x^2 + h^2}$

Differentiating the equation, we get

$$\frac{dy}{dy} = \frac{x}{2\sqrt{h^2 + x^2}}\frac{d}{dt} \Rightarrow V_B = \frac{xV_A}{2\sqrt{h^2 + x^2}}$$



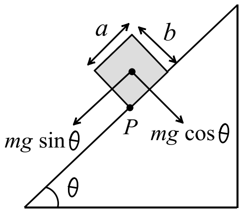
100 **(a)**

$$a = \frac{\sqrt{R_1^2 + R_2^2}}{m} = \frac{R_3}{m} \quad \left[\therefore\ R_3 = \sqrt{R_1^2 + R_2^2}\right]$$

101 **(b)**

For rotational equilibrium about point "P",

$$mg \sin \theta \left(\frac{b}{2}\right) = mg \cos \theta \left(\frac{a}{2}\right)$$



$\Rightarrow \tan\theta = \dfrac{a}{b} = \dfrac{10}{15} = \dfrac{2}{3}$

$\Rightarrow\ \theta = 33.69°$

$i.e.$, toppling starts at $\theta = 33.69°$

and angle of repose $= \tan^{-1}(\mu) = \tan^{-1}(\sqrt{3}) =$ 60°

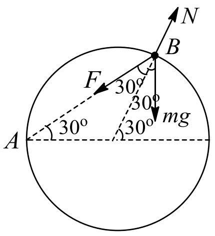
It mean the block will remain at rest on the plane up to certain angle θ and then it will topple

102 **(d)**

Extension in the string is

$x = AB - R = 2R\cos 30° - R = (\sqrt{3}-1)R$

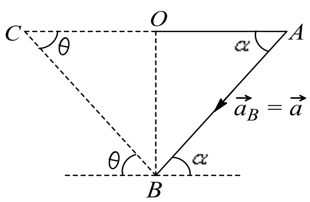
Spring force: $F = kx = \frac{(\sqrt{3}+1)mg}{R} \times (\sqrt{3}-1)R =$ $2mg$



From the figure, we have $N = (F + mg)\cos 30° = \frac{3\sqrt{3}mg}{2}$

103 **(d)**

Direction of acceleration of B is along the fixed incline, and the of A is alonmg horizontal towards left



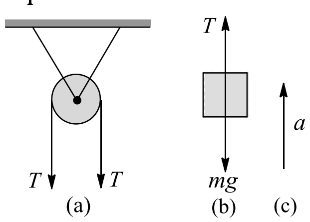
From diagram, acceleration of B is represented by $\overline{AB}$ while its horizontal and vertical components are shown by AO and OB, respectively.

Acceleration of A is represented by $\overline{AC}$

$\vec{O}C = a(\sin\alpha\cot\theta + \cos\alpha)$

104 **(b)**

Equation of motion for M:



Since M is stationary

$T - Mg = 0\ \Rightarrow T = mg$

Since the boy moves up with an acceleration a

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

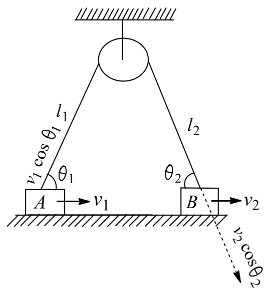
Equating Eqs. (i) and (ii), we obtain

$Mg = m(g + a)$

$\Rightarrow\ \ a = \left(\frac{M}{m} - 1\right)$ g, the block M can be lifted

105 **(c)**

From figure $\ell_1 + \ell_2 = C\ \ or\ \frac{d\ell_1}{dt} + \frac{d\ell_2}{dt} = 0$



$-v_1\cos\theta_1 + v_2\cos\theta_2 = 0$ or $\frac{v_1}{v_2} = \frac{\cos\theta_2}{\cos\theta_1}$

106 **(a)**

Velocity of object w.r.t. non-inertial frame is constant and hence w.r.t. some inertial frame of reference it is changing, hence it is acceleration. So net force acting on the object must be non-zero

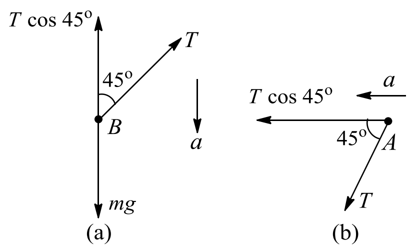
107 **(a)**

Let the total mass of the chain be M and mass of the hanging part be m_1. Then the mass of the part placed on table will be $m_2 = M - m_1$

Here weight of the hanging part will be balanced by the friction force acting on the upper part, i.e. $m_1 g = \mu m_2 g$ solve to get $(m_1/M) \times 100 = 20\%$

108 **(d)**

As shown in figure (a) and (b) from FBD of $A\ T\cos 45° = ma$ (i)



From FBD of B:

$Mg - T\cos 45° = ma$ (2)

From (i) and(ii), we get $T = mg/\sqrt{2}$

109 **(b)**

For A: $T - 2g = 2a$ (i)

For B: $T_1 + 2g - T = 2a$ (ii)

For C: $2g - T_1 = 2a$ (iii)

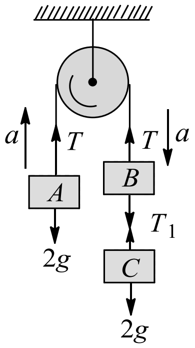
Adding (i) and (ii), we get

$T_1 = 4a$ (iv)

From Eq. (iii) and (iv), we get

$2g - 4a = 2a$

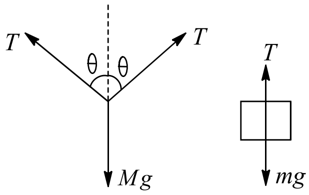
or $a = g/3$



From Eqs. (iv) and (v), $T_1 = 4 \times \frac{g}{3} = 13$ N

110 **(c)**

At equation $2T\cos\theta = Mg, T = mg$

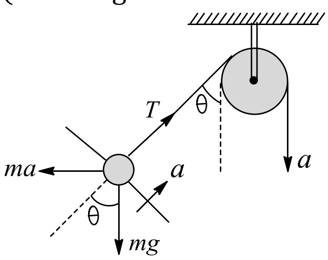


$$\cos\theta = \frac{Mg}{2mg} = \frac{M}{2m} \Rightarrow \cos\theta < 1$$

$$\frac{M}{2m} < 1 \Rightarrow M < 2m$$

111 **(c)**

(Check figure in the frame of the car)



Applying Newton's law perpendicular to string

$mg\sin\theta = ma\cos\theta \Rightarrow \tan\theta = \frac{a}{g}$

Applying Newton's law along string

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

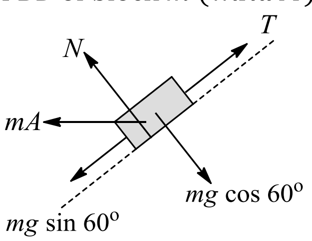
$\Rightarrow T = m\sqrt{g^2 + a^2} + ma$

112 **(b)**

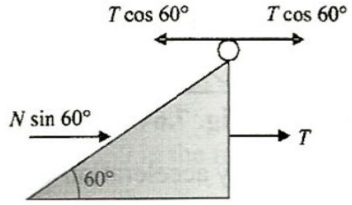
If initial acceleration of M towards right is A, thewn we can show that acceleration of m w.r.t. M down the incline is

$a = A(1 + \cos\theta) = \frac{3A}{2} \quad (\because \theta = 60°)$

FBD of block m (w.r.t. M) is shown below:



FBD of M (figure)



Equation of motion:

For m: $mg\frac{\sqrt{3}}{2} + mA \times \frac{1}{2} - T = m\frac{3}{2}A$ (i)

$N + mA\frac{\sqrt{3}}{2} = mg\frac{1}{2}$ (ii)

For M: $T + N\frac{\sqrt{3}}{2} = MA$ (iii)

From Eq. (i), (ii) and (iii) $A = \frac{3\sqrt{3}\,g}{23}$ ms^{-1}

113 **(c)**

From $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}at^2, t = \sqrt{\frac{2s}{a}}$

From smooth plane $a = g\sin\theta$

For rough plane, $a' = g(\sin\theta - \mu\cos\theta)$

$$\therefore \quad t' = nt \Rightarrow \sqrt{\frac{2s}{g(\sin\theta - \mu\cos\theta)}} = n\sqrt{\frac{2s}{g\sin\theta}}$$

$\therefore \quad n^2 g(\sin\theta - \mu\cos\theta) = g\sin\theta$

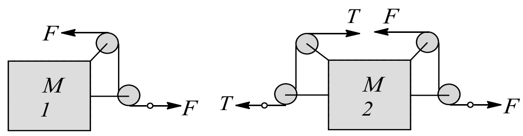
When $\theta = 45°, \sin\theta = \cos\theta = 1/\sqrt{2}$

Solving, we get $\mu = \left(1 - \frac{1}{n^2}\right)$

114 **(b)**

From FBD it is obvious that net force on each block is zero in horizontal direction. So

$a_1 = a_2 = 0$



115 **(c)**

Frictional force:

$F = mR = 0.5 \times mg = 0.5 \times 60 = 30$ N

Now $F = T_1 = T_2\cos 45°$ or $30 = T_2\cos 45°$

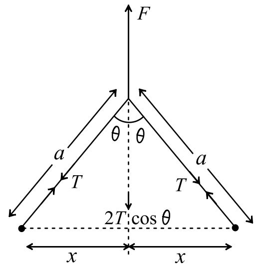
and $W = T_2\sin 45°$

Solving them, we get $W = 30$ N

116 **(b)**

$F = 2T\cos\theta$

$\Rightarrow T = \dfrac{F}{2\cos\theta}$



Magnitude of acceleration of the particle

$= \dfrac{T\sin\theta}{m}$

$= \dfrac{F\tan\theta}{2m} = \dfrac{F}{2m}\dfrac{x}{\sqrt{a^2 - x^2}}$

117 **(b)**

Change in momentum of one ball $= 2\,mu$, time taken $= 1$ s

$F_{\text{av}} = \dfrac{\text{Total chnage in momentum}}{\text{Time taken}}$

$= \dfrac{n(2\,mu)}{1} = 2\,mnu$

118 **(b)**

$a = \dfrac{3T - mg\sin\theta}{m}$

$= \dfrac{3 \times 250 - 100 \times 10 \times \sin 30°}{100} = 2.5\text{ ms}^{-2}$

119 **(b)**

The pressure on the rear side would be more due to fictitious force (acting in the opposite direction of acceleration) on the rear face. Consequently the pressure in the front side would be lowered

120 **(b)**

$\vec{u} = 4\hat{\imath} + 2\hat{\jmath}, \vec{a} = \dfrac{\vec{F}}{m} = \hat{\imath} - 4\hat{\jmath}$

Let at any time, the coordinate be (x, y)

$x - 2 = u_x t + \dfrac{1}{2}at^2$

$\Rightarrow x - 2 = 4t + \frac{1}{2}t^2$ *and* $y - 3 = 2t - \frac{1}{2}4t^2$

$\Rightarrow y - 3 = 2t - 2t^2$

When $y = 3$m, $t = 0, 1$ s; when $t = 0, x = 2$ m

When $t = 1$ s, $x = 6.5$ m

121 **(b)**

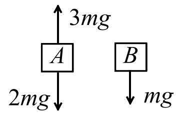
To move up with acceleration a, themonkey will, push the rope downwards with a force of

$T_{\text{min}} = mg + 40\,a_{\text{max}}$; $600 = 400 + 40\,a_{\text{max}}$

$a_{\text{max}} = \dfrac{200}{40} 5\text{ ms}^{-2}$

So rope will break if the monkey climbs up with acceleration 6 ms^{-2}

122 **(b)**



$a_A = g/2$

$a_B = g$

123 **(b)**

The force of 100 N acts on both the boats

$250\,a_1 = 100$ and $500a_2 = 100$

or $a_1 = 0.4\text{ ms}^{-2}$ and $a_2 = 0.2\text{ ms}^{-2}$

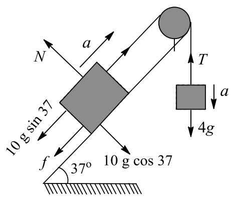
the relative acceleration: $a_2 = 0.2\text{ ms}^2$

Using $S = ut + \frac{1}{2}at^2$ we get

$100 = (1/2) \times 0.6 \times t^2$ or $t = 18.3$ s

124 **(a)**

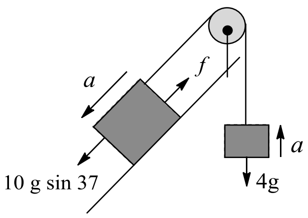
Let us first assume that the 4 kg block is moving down, then different forces acting on two blocks would be like as shown in the figure. (Normal to inclines forces are not shown in figure)



To have the motion, he friction force f should be equal to limiting value

i.e., $f_L = \mu_s mg\cos 37 = 0.27 \times 10\text{g} \times \frac{4}{5} = 2.16$ g

here, the 4 kg block is not able to pull the 10 kg block up the incline as $4\text{g} < 10\text{g}\sin 37 + f_L$, so system won't move in the direction that we assumed. So if there is a chance of motion of system, it can only move down the incline and system will move only if the net pulling force down the incline is greater than zero. For down the incline motion, the FBD is as shown in the figure



For a to be non-zero, i.e., positive

$10\text{g}\sin 37 > f_L + 4\text{g}$

Which is not, so the system is moving neither down the incline, nor up the incline and so the system remains at rest

125 **(b)**

For equilibrium

$\int \mu dmg\cos\theta \geq \int dmg\sin\theta$

or $\int \mu\lambda\, d\ell\, \text{g}\cos\theta \geq \int \lambda\, d\ell\, \text{g}\sin\theta$

$$\mu \int d\ell \cos\theta \geq \int d\ell \sin\theta$$

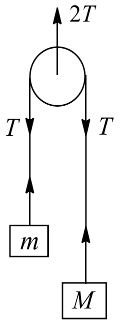
$$\left(\because \sin\theta = \frac{dy}{d\ell}, \cos\theta = \frac{dx}{d\ell}\right)$$

or $\mu \int dx \geq \int dy$ or $\mu\ell \geq h$

126 **(b)**

$$T = \frac{2m\,Mg}{m+M} = \frac{2mg}{1+\frac{m}{M}} \cong 2\,mg$$

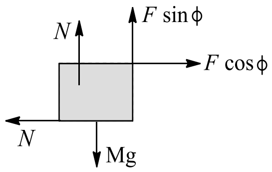
Hence, total downward force is $2T = 4\,mg$



127 **(c)**

$N = Mg - F\sin\phi$

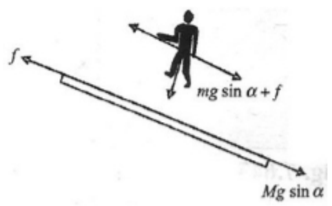
From figure



$$a = \frac{F\cos\phi - \mu(Mg - F\sin\phi)}{M}$$

128 **(b)**

Free-body diagram of man and plank is given below figure



For plank to be at rest, applying Newton's second law to plank along the incline

$Mg\sin\alpha = f$ (i)

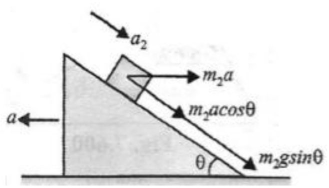
And applying Newton's second law to man along the incline

$mg\sin\alpha + f = ma$ (ii)

$\Rightarrow a = g\sin\alpha\left(1 + \frac{M}{m}\right)$ down the incline

129 **(a)**

In first case, acceleration of m_1 will be $a_1 = g\sin\theta$ down the inclined plane. In second case,



Acceleration of m_2 w.r.t. incline is

$$a_2 = \frac{m_2 g\sin\theta + m_2 a\cos\theta}{m_2} \Rightarrow a_2 = g\sin\theta + a\cos\theta$$

Since $a_2 > a_1$, so $T_2 < T_1$

130 **(c)**

Maximum frictional force on block B is

$\mu m_B g = 0.4 \times 3 \times 10 = 12$ N

Hence, maximum acceleration $= \frac{12}{3} = 4$ ms^{-1}

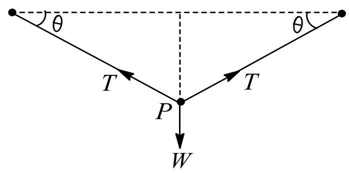
Hence, maximum force

$F = (m_A + m_B)a = (6+3) \times 4 = 36$ N

Aliter: We can also apply the formula discussed in previous problem by putting $\mu_2 = 0$ and $\mu_1 = 0.4$

131 **(d)**

When a string is fixed horizontally (by champing its free ends) and loaded at the middle, then for the equilibrium of point P



$2T\sin\theta = W$

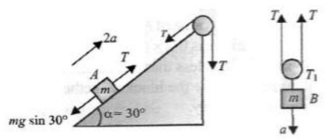
i.e., $T = \frac{W}{2\sin\theta}$

Tension in the string will be maximum when $\sin\theta$ is minimum, i.e., $\theta = 0°$ or $\sin\theta = 0$ and then$T = \infty$. However, as every string can bear a maximum finite tension (lesser than breaking strength), this situation cannot be realized practically. We conclude that a string can never remain horizontal when loaded at the middle howsoever great may be the tension applied

132 **(d)**

For b (figure)

$mg - 2T = ma$



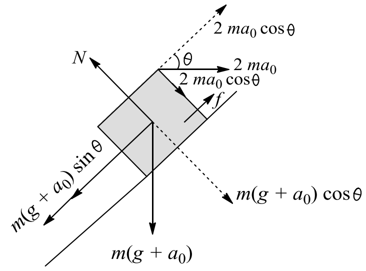
For A,

$$T - \frac{mg}{2} = m(2a)$$

Solving $a = 0$

133 **(d)**

The FBD of block from lift frame is as shown in figure. From given data, as $m(g + a_0)\sin\theta > 2\,ma_0\cos\theta$



So friction force acts upwards

$f = m(g + a_0) \sin\theta - 2ma_0 \cos\theta$

$= \frac{9g}{10} - \frac{4mg}{5} = \frac{mg}{10}$

$N = m(g + a_0) \cos\theta + 2ma_0 \sin\theta = \frac{9mg}{5}$

As $f_L = \mu_s N = \frac{18mg}{50} = \frac{9mg}{25} > f$ so static friction

Reaction force,

$$R = \sqrt{f^2 + N^2} = \frac{mg}{5}\sqrt{\frac{1}{4} + 9^2} = \frac{mg\sqrt{13}}{2}$$

Alternative solution:

Net force $\vec{F} - mg\hat{\imath} = m(a_0\hat{\jmath} - 2a_0\hat{\imath})$

$\Rightarrow \vec{F} = m(-2a_0\hat{\imath} + (a_0 + g)\hat{\jmath}) \Rightarrow \vec{F}$

$= m\left(-g\hat{\imath} + \frac{3g}{2}\hat{\jmath}\right)$

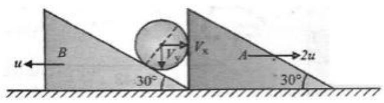
$$\Rightarrow F = m\sqrt{g^2 + \left(\frac{3g}{2}\right)^2} = \frac{\sqrt{13}mg}{2}$$

134 **(d)**

Method-1:Velocity components perpendicular to the comtact surface remain same

As cylinder will remain in contact with wedge A, (figure)

$V_x = 2u$



As it also remain in contact with wedge B

$u \sin 30° = V, \cos 30° - V, \sin 30°$

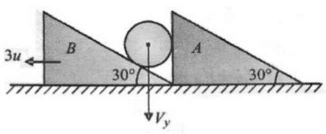
$V_y = V_x \frac{\sin 30°}{\cos 30°} + \frac{u \sin 30°}{\cos 30°}$

$V_y = 3u \tan 30° = \sqrt{3}\, u$

$\Rightarrow V = \sqrt{V_x^2 + V_y^2} = \sqrt{7}u$

Method-2

In the frame of A



$3u \sin 30° = V_y \cos 30°$

$V_y = 3u \tan 30° = \sqrt{3}\, u$ and $V_x = 2u$

$\Rightarrow \quad V = \sqrt{V_x^2 + V_y^2} = \sqrt{7}\, u$

135 **(a)**

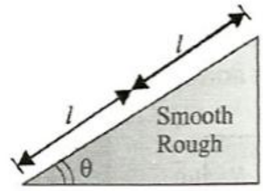
Since there in no resultant external force, linear momentum of the system remains constant

136 **(a)**

For first half acceleration $= g \sin\phi$

Therefore, velocity after travelling half distance

$v^2 = 2(g \sin\phi)l \quad$ (i)



For second half, acceleration $= g(\sin\phi - \mu_k \cos\phi)$

So $0^2 = v^2 + 2g(\sin\phi - \mu_k \cos\phi)\ell \quad$ (ii)

Solving (i) and (ii), we get $\mu_k = 2 \tan\phi$

137 **(c)**

Given horizontal force $F = 25$ N and coefficient of friction between block and wall $(\mu) = 0.4$

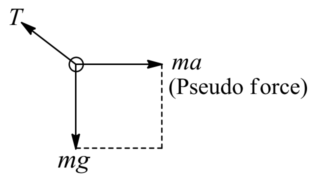
We know that at equilibrium horizontal force provides the normal reaction to the block against the wall. Therefore, normal reaction to the block $(R) = F = 25$ N

We also know that weight of the block $(W) =$ Frictional force$= \mu R = 0.4 \times 25 = 10$ N

138 **(b)**

Acceleration of box $= 10$ ms^{-2}

Inside the box forces acting on bob (see figure)



$T = \sqrt{(mg^2) + (ma)^2} = 10\sqrt{2}$ N

139 **(c)**

$a_{B,g} = \sqrt{b^2 + c^2 + 2bc\cos(180 - \theta)}$

$$= \sqrt{b^2 + \left(\frac{b\cos\theta}{2}\right)^2 + bb\cos\theta\,(-\cos\theta)}$$

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

$$= \frac{2g\sin\theta}{\sqrt{1 + 3\sin\theta}}$$

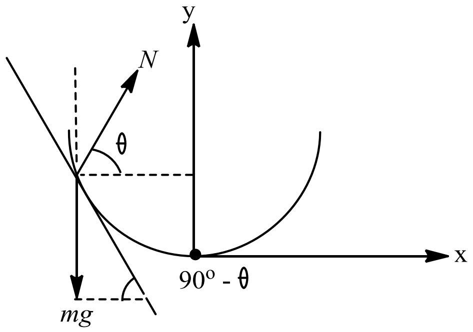
140 **(d)**

$N \sin\theta = mg$

$N \cos\theta = ma$

$\tan\theta = \frac{g}{a}$

$\cos\theta = \frac{a}{8} = \tan(90° - \theta) - \frac{dy}{dx} = 2k\, x$



$\therefore x = \dfrac{a}{2k\,g}$

141 **(a)**

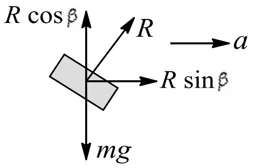
As m_2 moves with constant velocity, there is no acceleration in the centre of mass. Net force should be zero. For this $N = m_1 g + m_2 g$

142 **(a)**

Acceleration of the system

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

The FBD of mass m is shown in the figure



$R \sin\beta = ma$ (ii)

$R \cos\beta = mg$ (iii)

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

$a = g\tan\beta$

Putting the value of a in (i), we get

$P = (M+m)g\tan\beta$

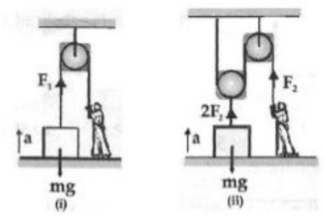
143 **(a)**

Since, $h = \frac{1}{2}at^2$, a should be same in both cases, because h and t are same in both cases as given

In figure (i), $F_1 - mg = ma \Rightarrow F_1 = mg + ma$

In figure (ii), $2F_2 - mg = ma \quad F_2 = \frac{mg+ma}{2}$

$\therefore F_1 > F_2$



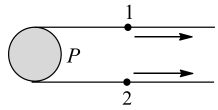
144 **(c)**

Tx(Hanged part) $= 2Tx'$(Sliding part)

$\therefore \; x = 3x' \;\Rightarrow\; x = 3 \times 0.6 = 1.8\ \text{ms}^{-1}$

145 **(c)**

If we take two points 1 and 2 on the string near the pulley P as shown, then velocities of both points 1 and 2 will be same. Hence, P does not rotate but only translate



146 **(a)**

Initial force $= 2g = 20$ N

Initial acceleration$= \frac{\text{Force}}{\text{Mass}} = \frac{20}{5+1} = \frac{20}{6}\text{ms}^{-2}$

Final force=(load+mass of thread)$\times$ g

$= (2+1) \times 10 = 30$ N

$\therefore$ final acceleration$= \frac{30}{6}\text{ms}^{-2}$

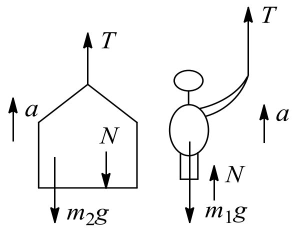
147 **(d)**

Same solution for both

$m_1 = 100$ kg, $m_2 = 50$ kg, $a = 5\ \text{ms}^{-2}$

$T + N - m_1 g = m_1 a, T - N - m_2 g = m_2 a$

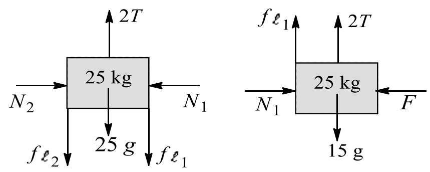
Solving these : $T = -1125$ N and $N = 375$ N



148 **(c)**

In the absence of friction, we can find that 15 kg will accelerate downwards and 25 kg upwards. So various forces acting on these will be as shown

$N_2 = N_1 = F, f_{\ell_1} = \mu N_1 = 0.4F, f_{\ell_2} = \mu N_2 = 0.4\,F$



For 15 kg: $T + f_{l_1} + 15\text{ g} \Rightarrow T + 0.4\,F = 15\text{ g}$ (i)

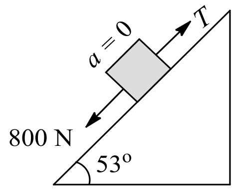
For 25 kg: $2T = f_{\ell_1} + f_{\ell_2} + 25\text{g}$

$\Rightarrow \; 2T = 0.8\,F + 25\text{g}$ (ii)

Solve (i) and (ii) to get $F = 31.25$ N

149 **(c)**

For block to be stationary, $T = 800$ N



If man moves up by acceleration **'a**

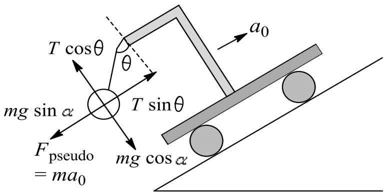
$T - mg = ma$

$800 - 500 = 50\alpha \quad a = 6\text{ms}^{-2}$

150 **(d)**

As in figure

$T\sin\theta = ma_0 + mg\sin\alpha$



$T\cos\theta = mg\cos\alpha$

$\tan\theta = \dfrac{a_0 + g\sin\alpha}{g\cos\alpha}$

151 **(a)**

If the plane makes an angle θ with horizontal, thentan $\theta = 8/15$. If R is the normal reaction

$R = 170\ g\cos\theta = 170 \times 10 \times \left(\dfrac{15}{17}\right) = 1500\ N$

Force of friction on $A = 1500 \times 0.2 = 300$ N

Force of friction ob $B = 1500 \times 0.4 = 600$ N

Considering the two blocks as a system, the net force parallel to the plane is

$= 2 \times 170g\sin\theta - 300 - 600 = 1600 - 900 = 700$ N

$\therefore$ Acceleration $= \dfrac{700}{340} = \dfrac{35}{17}\text{ms}^{-2}$

Consider the motion of A alone

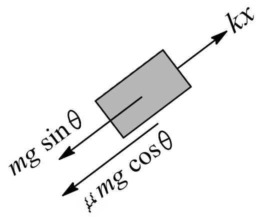
$170\ g\sin\theta - 300 - P = P\ 170 \times \dfrac{35}{17}$

(where P is pull on the bar)

$P = 500 - 350 = 150$ N

152 **(a)**

Let m start moving down and extension produced in spring be x at any time. Value of x required to move the block m is



$kx = \mu\ mg\cos\theta + mg\sin\theta$

$\Rightarrow kx = 0.5\ mg\dfrac{4}{5} + mg\dfrac{3}{5} = mg$

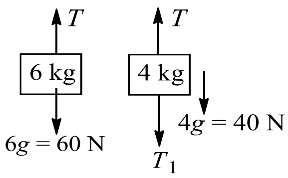
Fore minimum M, it will stop after producing extension in the spring x

$Mgx = \dfrac{1}{2}kx^2 \Rightarrow Mg = \dfrac{1}{2}kx$

$\Rightarrow Mg = \dfrac{1}{2}mg \quad \Rightarrow M = \dfrac{m}{2}$

153 **(a)**

$T = 60$ N, $T = T_1 + 40$



$\Rightarrow 60 = T_1 + 40 \Rightarrow T_1 = 20$ N

154 **(d)**

$a_1 = \dfrac{(m_2 - m_1)g}{(m_1 + m_2)}$ and $a_2 = \dfrac{(m_2 - m_1)g}{m_1}$

Hence $\dfrac{a_1}{a_2} = \dfrac{m_1}{(m_1+m_2)} = \dfrac{1}{\left(1+\frac{m_2}{m_1}\right)} \quad \Rightarrow \quad \dfrac{a_1}{a_2} < 1$

As $T_1 = \dfrac{2m_1m_2g}{(m_1+m_2)}$ and $T_2 = m_2g$

Hence $\dfrac{T_1}{T_2} = \dfrac{2m_1}{(m_1+m_2)} = \dfrac{2}{\left(1+\frac{m_2}{m_1}\right)}$

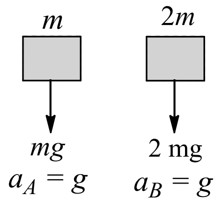
$\dfrac{T_1}{T_2}$ will depend upon the values of m_1 and m_2

$N = 2T_1, N_2 = 2T_2$

So the relation of N_1/N_2 will, be same as $\dfrac{T_1}{T_2}$

155 **(a)**

In this case, spring force is zero initially. FBD of A and B are shown below

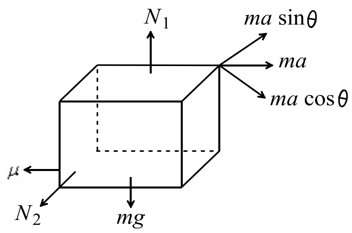


Tension in the string and spring will be zero just after release

156 **(a)**

Making FBD of block with respect to disc

Let A be the acceleration of block with respect to disc



$N_1 = mg$

$N_2 = m\ a\sin\theta$

$A = \dfrac{m\ a\cos\theta - \mu N_2 - \mu N_1}{m} = 10m/s^2$

157 **(b)**

Acceleration of cylinder down the plane is

$a = (g\sin 30°)(\sin 30°) = 10\left(\dfrac{1}{2}\right)\left(\dfrac{1}{2}\right) = 2.5\ \text{ms}^{-1}$

Time taken $t = \sqrt{\dfrac{2s}{a}} = \sqrt{\dfrac{2\times5}{2.5}} = 2$s

158 **(a)**

Spring balance reads the tension in the string connected to its hook side. As the spring balance is light, the tension in the string on its either side is same. Now the only thing that remains to be found is the tension in the string which could be found easily by using Newton's second law

159 **(d)**

The minimum value of F required to be applied on the blocks to move is $0.2 \times (2+4) \times 10 = 12$ N. since the applied force is less than the minimum value of force required to move the blocks together, the blocks will remain stationary

160 **(d)**

Force acting on plate, $F = \frac{dp}{dt} = v\left(\frac{dm}{dt}\right)$

Mass of water reaching the plate per $sec = \frac{dm}{dt}$

$= Av\rho = A(v_1+v_2)\rho = \frac{V}{v_2}(v_1+v_2)\rho$

($v = v_1 + v_2 =$ velocity of water coming out of jet $w.r.t.$ plate)

$\left[A = \text{Area of cross section of jet} = \frac{V}{v_2}\right]$

$\therefore F = \frac{dm}{dt}v = \frac{V}{v_2}(v_1+v_2)\rho \times (v_1+v_2)$

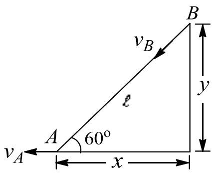
$= \rho\left[\frac{V}{v_2}\right](v_1+v_2)^2$

161 **(d)**

Due to malfunctioning of engine, the process of rocket fusion stops and hence net force experienced by spacecraft becomes zero. Afterwards the spacecraft continues to move with constant speed

162 **(b)**

Here y is constant $\frac{d\ell}{dt} = v_B$



$\ell^2 = y^2 + x^2 \;\;\Rightarrow\;\; 2\ell\frac{d\ell}{dt} = 2x\frac{dx}{dt}$

$\Rightarrow\;\; v_B = \frac{x}{\ell}v_A = v_A\cos 60° = 1\ \text{ms}^{-1}$

163 **(a)**

Acceleration of the skaters will be in the ratio

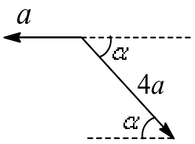
$\frac{F}{4}:\frac{F}{5}$ or $5:4$

Now according to the problem, $s = 0 + \frac{1}{2}at^2$

We get $\frac{s_1}{s_2} = \frac{a_1}{a_2} = \frac{5}{4}$

164 **(b)**

If the wedge moves leftwards by x, then the block moves down the wedge by $4x$, i.e. w.r.t. wedge the block comes sown by $4x$



So, acceleration of block w.r.t. wedge= $4a$ along the incline plane of wedge

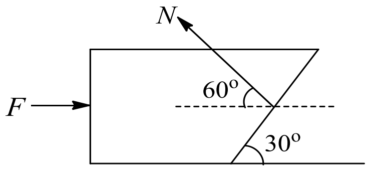
Acceleration of wedge with respect to ground= a, alonm gleft. So acceleration of block w.r..t ground is the vector sum of two vectors shown in the figure. That is

$|\vec{a}_{BG}| = \sqrt{a^2 + (4a)^2 + 2 \times a \times 4a \times \cos(\pi - \alpha)}$

$= (\sqrt{17 - 8\cos\alpha})a\ \text{ms}^{-2}$

165 **(d)**

Acceleration of two mass system is $a = \frac{F}{2m}$ leftwards. FBD of block A is shown in below



$N\cos 60° - F = ma = \frac{mF}{2m}$

Solving, we get $N = 3\,F$

166 **(a)**

$\tan\theta = v^2/Rg \;\Rightarrow \frac{h}{b} = v^2/Rg \;\Rightarrow h = \frac{v^2 b}{Rg}$

167 **(b)**

The acceleration of the body perpendicular to OE is

$a = \frac{F}{m} = \frac{4}{2} = 2\ \text{ms}^{-2}$

Displacement along $OE, s_1 = vt = 3 \times 4 = 12$ m

Displacement perpendicular to OE

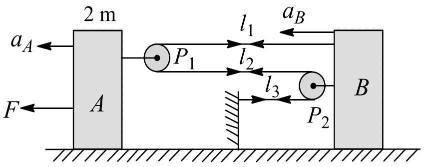
$s_2 = \frac{1}{2}at^2 = \frac{1}{2} \times 2 \times (4)^2 = 16$m

The resultant displacement

$s = \sqrt{s_1^2 + s_2^2} = \sqrt{144 + 256} = \sqrt{400} = 20$ m

168 **(b)**

As in figure



$\ell_1 + \ell_2 + \ell_3 = C$

$\ell_1' + \ell_2' + \ell_3' = 0$

$-V_B + V_A - V_B + V_A - V_B = 0$

$3V_B = 2V_A \;\;\Rightarrow\;\; 3a_B = 2a_A$

Applying Newton's law on A and B

$F - 2T = 2\,ma_A, 3T = 2ma_B$

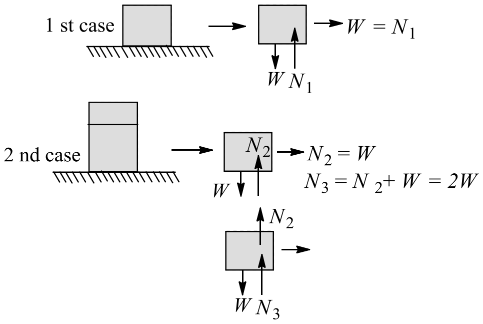
Solve to get $a_B + \frac{3F}{13m}$

169 **(b)**

$\vec{a}_{b,\ell} = \vec{a}_b - \vec{a}_\ell = (g - a)\downarrow \Rightarrow\; \vec{a}_b = g\downarrow$

170 **(c)**

Let the weight of each block be W (figure)



So, $N_1 = N_2 = \frac{N_3}{2}$

171 **(c)**

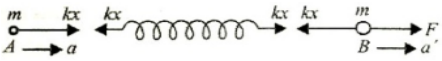
Equation of motion for A (figure)

$kx = ma \quad \Rightarrow \quad a = \dfrac{kx}{m}$

For $B: F - T = ma'$

$\Rightarrow \quad a' = \dfrac{F - kx}{m}$

$\Rightarrow$ The relative acceleration $= a_r = |a' - a| = \frac{F-2kx}{m}$



172 **(d)**

As there is no tendency of relative slipping between the block and cube, the friction force is zero

173 **(d)**

From 0 to$T$, area is positive and from T to 2 T, area is negative. Net area is zero. Hence no change in momentum occurs

174 **(c)**

Acceleration is to be downward which is possible in option (c)

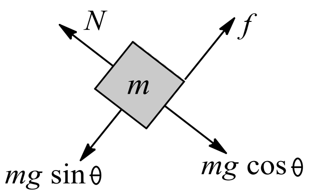
175 **(c)**

Area under the force— time graph is impulse, and impulse is change in momentum

Area of graph=change in momentum

$\Rightarrow \dfrac{1}{2} TF_0 = 2\,mu \Rightarrow F_0 = \dfrac{4mu}{T}$

176 **(a)**



$N = mg\cos\theta\,, f = mg\sin\theta$

Net force applied by M on m (or m on M):

$F = \sqrt{N^2 + f^2}$

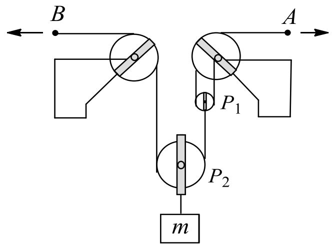
$= \sqrt{(mg\cos\theta)^2 + (mg\sin\theta)^2} = mg$

177 **(a)**

$V_A = 2\text{ ms}^{-1}$ (towards right)

$\therefore \quad V_{P_1} = \frac{V_A}{2} = 1\text{ ms}^{-1}$ (upwards)

$V_A = 2\text{ ms}^{-1}$ (towards left)



Now $\quad 2V_{P_2} = V_B + V_{P_1} \therefore V_{P_2} = \frac{V_B + V_{P_1}}{2} = \frac{2+1}{2} = 1.5\text{ ms}^{-1}$

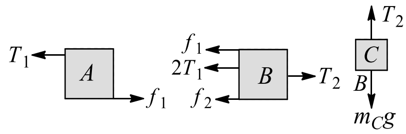
178 **(d)**

Maximum friction that can be obtained between A and B is $f_1 = \mu m_A g = (0.3)(100)(10) = 300\,N$ and maximum

Friction between B and ground is

$f_2 = \mu(m_A + m_B)\text{g} = (0.3)(100 + 140)(10) = 720$ N

Drawing free-body diagrams of A, B and C in limiting case



Equilibrium of A gives

$T_1 = f_1 = 300$ N (1)

Equilibrium of B gives

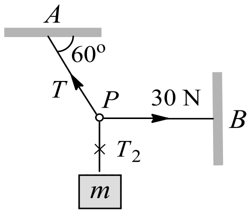
$2T_1 + f_1 + f_2 = T_2$

or $T_2 = 2(300) + 300 + 720 = 1620$ N (2)

and equilibrium of C gives $m_C\text{g} = T_2$

or $10\,m_C = 1620$ or $m_C = 162$ kg

179 **(c)**



$T\cos 60° = 30\text{ N} \Rightarrow T = 60$ N

$T\sin 60° = T_2 = W \Rightarrow W = 60\frac{\sqrt{3}}{2} = 30\sqrt{3}$ N

180 **(a)**

On the system of particle if,

$\sum \mathbf{F}_{\text{ext}} = 0$

then $\mathbf{P}_{\text{system}} = \text{constant}$

No other conclusions can be drawn.

181 **(c)**

Let T be the tension in the rope and a the acceleration of rope. The absolute acceleration of man is, therefore, $\left(\frac{5\text{g}}{4} - a\right)$. Equations of motion for mass and man gives:

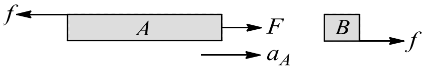
$T - 100g = 100a$ (i)

$T - 60g = 60\left(\frac{5g}{4} - a\right)$ (ii)

Solving (i) and (ii), we get $T = \frac{4875}{4} N$

182 **(a,b,c)**

As the acceleration of A and B are different, it means there is relative motion between A and B. The free-body diagram of A and B can be drawn as below



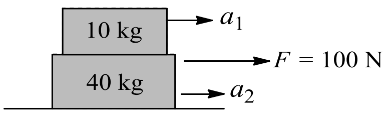
For $A, F - f = Ma_A = 50 \times 3$

For $B, f = ma_B = 20 \times 2 \Rightarrow f = 40$ N, $F = 190$ N

183 **(a,b)**

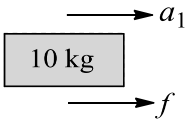
Because mg acts downwards which makes sliding along 4 to be easiest and along 4 to be difficult most

184 **(b,c)**



$F = 10a_1 + 40a_2$

$\Rightarrow 100 = 10a_1 + 40 \times 2 \quad \Rightarrow \quad a_1 2 \text{ ms}^{-2}$



So acceleration of A must be 2 ms^{-2} for given conditions to be satisfied

$f \le f_\ell \quad \Rightarrow \quad 20 \le \mu m_A g$

$\Rightarrow \quad 20 \le \mu \times 10g \quad \Rightarrow \quad \mu \ge 0.2$

Hence, m can be greater or equal to 0.2

185 **(a,b,c)**

Here $m_1 g \sin 30° = m_2 g = 20$ N, so there is no tendency of motion in any direction

Hence there is no friction on m_1. Contact force will be only normal force

186 **(a,b,c)**

1. Let acceleration of each block be a

$10g - T_2 = 10a, \quad T_2 - T_1 - f = 3a$

$T_1 - f = 2a, \quad$ where $f = 0.3 \times 2g = 6$ N

From above equations

$10g - 2f = 15a \quad \Rightarrow 10 \times 10 - 2 \times 6 = 15a$

$\Rightarrow a = 88/15 \text{ms}^{-2}$

$$T_2 = 10g - 10a = 10 \times 10 - 10 \times \frac{88}{15} = 41.3 \text{ N}$$

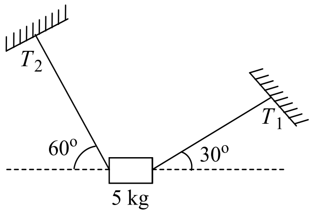
$$T_1 = f + 2a = 6 + 2 \times \frac{88}{15} = 17.7 \text{ N}$$

Clearly $T_2 > T_1$

2. This is correct because of greater mass of 3 kg since acceleration is same for both

3. This is incorrect, because net force acting on 10 kg mass is greater due to its larger mass, not due to its acceleration downward

187 **(a,d)**



$T_2 \cos 60° = T_1 \cos 30°$ (i)

And $T_2 \sin 60° + T_1 \sin 30° = 5g$ (ii)

From (i) and (ii)

$T_1 = 25$ N and $T_2 = 25\sqrt{3}$ N

188 **(b,c)**

Force of upthrust will be there on mass m shown in figure, so A weighs less than 2 kg. Balance will show sum of load of beaker and reaction of upthrust so it is reads nore than 5 kg

189 **(b,c)**

Here $F > \mu, mg\left(1 + \frac{m}{M}\right)$, so slipping will occur between the blocks

Fro $mF - \mu_k mg = m.a \quad \Rightarrow \quad a = 1.2 \text{ ms}^{-2}$

For $M\mu_k mg = MA \quad \Rightarrow \quad A = 0.4 \text{ ms}^{-2}$

190 **(a,d)**

If initially acceleration of A is greater than that of B, then there will be extension and if that of B is greater than A, then there will be compression in the spring. Otherwise length of spring will remain same

191 **(a,b,c,d)**

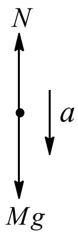
When friction between the blocks becomes zero, the relative sliding between the block will be stopped hence; $v_A = v_B$ and $a_A = a_B$. Also when the friction becomes zero, only forces to move the blocks are F_A and F_B

$$a_A = a_B \quad \Rightarrow \quad \frac{F_A}{m_A} = \frac{F_B}{m_B}$$

192 **(a,c)**

$Mg - T = Ma$ (i)

$T = ma$ (ii)



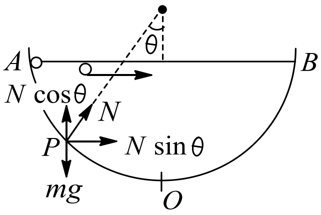
Solving (i) and (ii), $a = \frac{Mg}{M+m}$

FBD of man

$$Mg - N = Ma \Rightarrow N = \frac{Mmg}{(M+m)}$$

193 **(a)**

At A the horizontal speeds of both the masses is the same. The velocity of Q remains the same in horizontal as no force is acting on the horizontal direction. But in case of P as shown at any intermediate position, the horizontal velocity first increases (due to$N \sin\theta$), reaches a maximum value at O and then decreases. Thus it always remains greater than v, Therfore, $t_P < t_Q$



194 **(c)**

$$a = \frac{F}{m} = \frac{5 \times 10^4}{3 \times 10^7} = \frac{5}{3} \times 10^{-3}\ \mathrm{ms^{-2}}$$

$$v = \sqrt{2as} = \sqrt{2 \times \frac{5}{3} \times 10^{-3} \times 3} = 0.1\ \mathrm{ms^{-1}}$$

195 **(b,d)**

Option (a) is wrong since Earth is an accelerated frame and hence cannot be an inertial frame

Option (b) is correct

Option (c) is incorrect; strictly speaking as Earth is accelerated reference frame (earth is treated as a reference frame for practical examples and Newton's law's are applicable to it only as a limiting case)

Option (d) is correct

196 **(a,b,d)**

Newton's second law is $\vec{F} = \frac{d\vec{p}}{dt}$, which itself explains the validity of the given statements

197 **(d)**

Rate of flow water $\frac{v}{t} = 10\ \mathrm{cm^3 s^{-1}}$

$= 10 \times 10^{-6}\ \mathrm{m^3 s^{-1}}$

Density of water $\rho = \frac{10^3 \mathrm{kg}}{\mathrm{m^3}}$

Cross-sectional area of pipe $A = \pi(0.5 \times 10^{-3})^2$

Force $= m\frac{dv}{dt} = \frac{mv}{t} = \frac{V\rho v}{t} = \frac{\rho v}{t} \times \frac{v}{At}$

$= \left(\frac{v}{t}\right)^2 \frac{l}{A} \quad \left(\because v = \frac{v}{At}\right)$

$$F = \frac{(10 \times 10^{-6})^2 \times 10^3}{\pi \times (0.5 \times 10^{-3})^2}$$

$= 0.127$ N

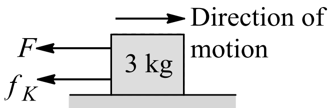
198 **(a)**

Since, $\mu\, mg \cos\theta > mg \sin\theta$

Force of friction is $f = mg \sin\theta$

199 **(b,c,d)**

For some time, the block won't move due to friction force. When $F > f_L$, the motion of block starts



$$a = \frac{F - f_k}{m} = \frac{kt - f_k}{m} \Rightarrow \frac{dv}{dt} = a = \frac{kt - f_k}{m}$$

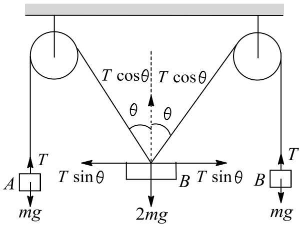
$$v = \frac{\frac{kt^2}{2} - f_k t}{m} \Rightarrow \frac{ds}{dt} = \frac{\frac{kt^2}{2} - f_k t}{m} \Rightarrow s = \frac{\frac{kt^3}{6} - \frac{f_k t^2}{2}}{m}$$

200 **(b)**

$F = m\frac{dv}{dt} = 0.05 \times \frac{100}{0.02} = 250$ N

201 **(c)**

For equilibrium in vertical direction for body B we have



$\sqrt{2}\, mg = 2T\cos\theta = 2(mg)\cos\theta$

$T = mg$ (at equilibrium)

$\therefore \cos\theta = \frac{1}{\sqrt{2}} \Rightarrow \theta = 45°$

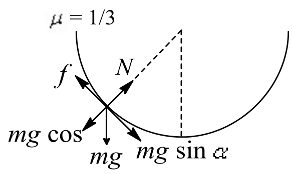
202 **(a)**

The two forces acting on the insect are mg and N.

Let us resolve mg into two components:

$mg\cos\alpha$ balances N

$mg \sin\alpha$ is balanced by the frictional force



$N = mg\cos\alpha$

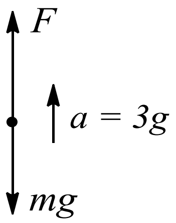
$f = mg\sin\alpha$

But $f = \mu N = \mu\, mg\cos\alpha$

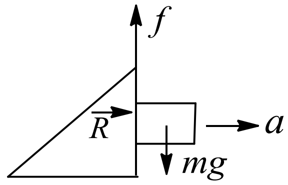
$\Rightarrow \cot\alpha = \frac{1}{\mu} \Rightarrow \cot\alpha = 3$

203 **(a,b,c,d)**

a



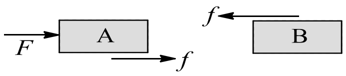
$F - mg = ma$
$F = m(\mathrm{g} + a) = 4mg = 4W$
b Think of Newton's third law of motion



c $mg < f_{\max}$
or $mg < \mu_s R$ or $mg < \mu_s ma$
or $\mathrm{g} < \mu_s a$ or $\mu_s a > \mathrm{g}$ or $\mu_s > \frac{\mathrm{g}}{a}$
d The jumping away of the man involved upward acceleration. It means an upward force acts on man during jumping. Then from third law, a downward force acts on platform due to which reading first increases

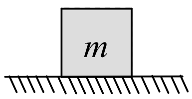
204 **(a,c,d)**
In first case, m will remain at rest.$a_M = F/M$
In second case, both will accelerate
$a_m = a_M = F/(M+m)$
In second case, force on $m = ma_m = mF/(M+m)$

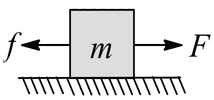
205 **(a,b,c)**
Friction on A and B acts as shown



From the figure it is clear that friction on A supports it motion and on B opposes its motion. And friction always opposes relative motion

206 **(a,b,c)**
For (i); Consider a block at rest on a rough surface and no force (horizontal) is acting on it. Now friction force on it would be zero. For (ii): Consider a heavy block, under the application of small force F which is not sufficient to cause its motion, so friction force is static in nature and block doesn't move

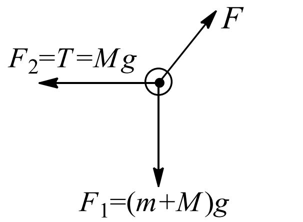




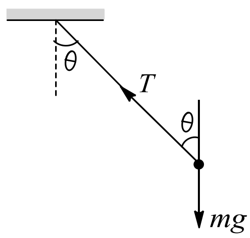
For (iii): Refer to concepts and formulae
For (iv): Friction force and normal force always act perpendicular to each other

207 **(a,c)**
In region AB and CD, slope of the graph is constant $i.e.$ velocity is constant. It means no force acting on the particle in this region

208 **(d)**
Force on the pulley are
$F = \sqrt{F_1^2 + F_2^2}$
$= \left(\sqrt{(m+M)^2 + M^2}\right)\mathrm{g}$

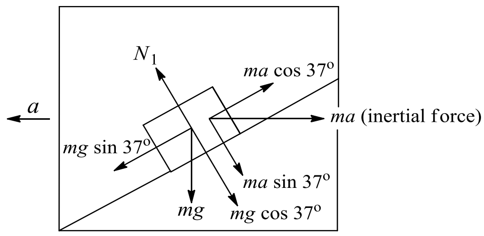


209 **(c)**

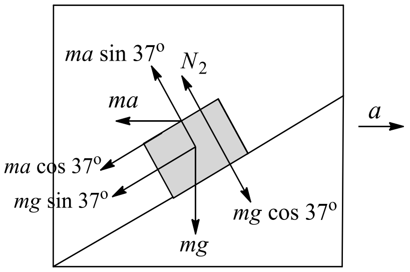


FBD of bob is $T\sin\theta = \frac{mv^2}{R}$
and $T\cos\theta = mg$
$\tan\theta = \dfrac{v^2}{R\mathrm{g}} = \dfrac{(10)^2}{(10)(10)}$
$\tan\theta = 1$
or $\theta = 45°$

210 **(a,c)**

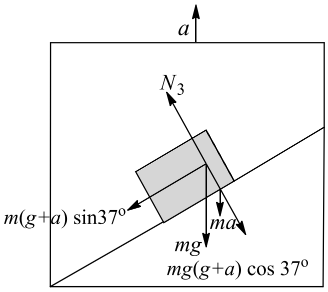


Balancing forces perpendicular to incline
$N_1 = mg\cos 37° + ma\sin 37°$
$N_1 = \dfrac{4}{5}mg + \dfrac{3}{5}ma$
And along incline, $mg\sin 37° - ma\cos 37° = mb_1$
$b_1 = \dfrac{3}{5}g - \dfrac{4}{5}a$



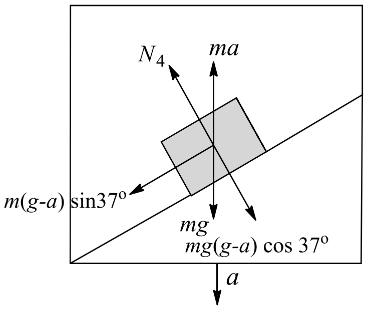
Similarly for this case get $n_2 = \frac{4}{5}MG - \frac{3}{5}MA$

And $b_2 = \frac{3}{5}\text{g} + \frac{4}{5}a$



Similarly for this case get $N_3 = \frac{4}{5}mg + \frac{4}{5}ma$

$$b_3 = \frac{3}{5}g + \frac{3}{5}a$$



Similarly for this case, get $N_4 = \frac{4}{5}mg - \frac{4}{5}ma$

And $b_4 = \frac{3}{5}\text{g} - \frac{3}{5}a$

211 **(a,b,c)**

If the block is at rest, then force applied has to be greater than limiting friction force for its motion to begin

$f_L = \mu_s mg = 0.25 \times 3\text{ g} = 7.5\ N < F_{\text{applied}}$

So friction is static in nature and its value would be equal to applied force, i.e., 7 N. if the body is initially moving, then kinetic friction is present ($f_k = \mu_k\ mg = 6\ N$), acting opposite to direction of motion

As $F > f_k$ the block is accelerated with an acceleration of $a = \left[\frac{F-f_k}{m}\right] = \frac{1}{3}\ ms^{-2}$ and hence its speed is continuously increasing

If applied force is opposite to direction of motion, then block is under deceleration of $a = -\left[\frac{F-f_k}{m}\right] = -\frac{13}{3}ms^{-2}$ and hence after some time block stops and kinetic friction vanishes but applied force continuous to act

But as $F < f_L$, the block remains at rest and friction force acquires the value equal to applied force, i.e. friction is static in nature

212 **(a)**

Total mass of 80 wagons

$= 80 \times 5 \times 10^3 = 4 \times 10^5$ kg

Acceleration, $a = \frac{F}{M} = \frac{4\times10^5}{4\times10^5} = 1\text{ ms}^{-2}$

Tension in the coupling between 30th and 31st wagon will be due to mass of remaining 50 wagons. Now, mass of remaining 50 wagons

$m = 50 \times 5 \times 10^3\text{kg} = 25 \times 10^4\text{kg}$

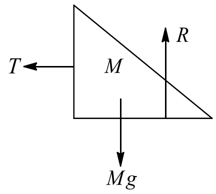
$\therefore$ Required tension, $T = mg = 125 \times 10^4 \times 1$

$= 25 \times 10^4$ N

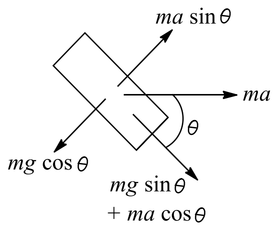
213 **(a,c)**

$M'\text{g} - T = M'a$ (i)

$T = Ma$ (ii)



$$M'\text{g} = a(M + M') \Rightarrow a = \frac{M'\text{g}}{(M + M')}$$



$ma \sin\theta = mg\cos\theta \rightarrow$ so that normal force is zero

$a = \text{g}\cot\theta$

$$\text{g}\cot\theta = \frac{M'\text{g}}{(M + M')} \Rightarrow \cot\theta M + \cot\theta M' = M'$$

$\cot\theta M + \cot\theta M' = M'$

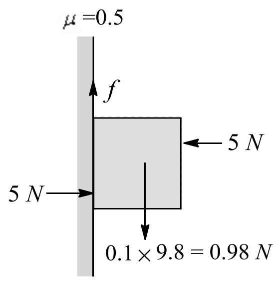
$$M' = \frac{M\cot\theta}{(1 - \cot\theta)}, T = Ma = Mg\cot\theta = Mg/\tan\theta$$

214 **(b)**

The magnitude of the frictional force f has to balance the weight 0.98 N acting downwards

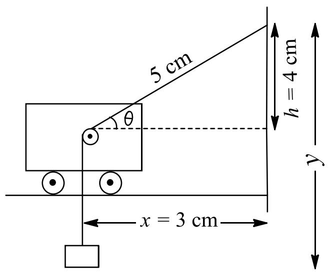
$f_\ell = 0.5 \times 5 = 2.5$ N

$f < F_\ell$



Therefore, the friction force is 0.98 N. Hence, option (b) is the correct option

215 **(c,d)**



$(y-h)+\sqrt{x^2+h^2}=\ell$ or $\dfrac{dy}{dt}+\dfrac{x}{\sqrt{x^2+h^2}}\dfrac{dx}{dt}$
$=0$

$\dfrac{dy}{dt}=-\dfrac{x}{\sqrt{x^2+h^2}}\dfrac{dx}{dt} \Rightarrow \dfrac{dy}{dt}=-\dfrac{3}{5}(-v_A)$

$V_B=\dfrac{3}{5}v_A$ (i)

$\dfrac{d^{2y}}{dt^2}=\dfrac{v_A^2h^2}{(x^2+h^2)^{3/2}} \Rightarrow a_B=v_A^2\dfrac{16}{(5)^3}$

$a_B=\frac{16}{125}v_A^2$(ii)

216 **(b)**

Let the velocity of the block M be v upwards, then
$v\cos\theta=U \Rightarrow v=U/\cos\theta$

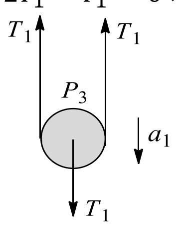
217 **(a,b,d)**

1. Since the body is accelerated, it can't have constant velocity, but it can have constant speed
2. If acceleration of the body is opposite to the velocity, then at some instant its velocity will become zero
3. As the body is accelerated, net force on it can't be zero
4. Forces may act at some angle also

218 **(a,c)**

First of all draw FBD ofP_3. Let tensions, in three strings be T_1, T_2 and T_3, respectively

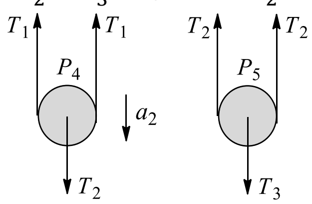
$2T_1-T_1=0\times a \Rightarrow T_1=0$



Now draw FBD of P_4 and P_5

$2T_1-T_2=0 \Rightarrow T_2=0$

$2T_2-T_3=0 \Rightarrow T_2=T_3=0$



So forces acting on P_6 and P_7 will be that of gravity and they will be in free fall. Hence, acceleration of each of them will be g downwards

219 **(b,d)**

In a non uniform field, $\sum\vec{\mathbf{F}}\neq 0$. When dipole is aligned with field $\sum\vec{\tau}=0$ and when dipole is not aligned, $\sum\vec{\tau}\neq 0$

220 **(b)**

As in clear from figure

$R+T=(m+M)$g

$R=(m+M)$g$-T$

The system will not move till

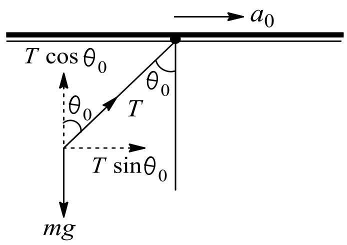
$T\leq F$ or $T\leq\mu R$

$T\leq\mu[(m+M)\text{g}-\text{T}]$

$T\leq\dfrac{\mu(m+M)\text{g}}{\mu+1}$

$\therefore\ F_{\max}=\dfrac{\mu(m+M)\text{g}}{\mu+1}$

221 **(a,d)**



$T\cos\theta_0=mg$ ...(i)

$T\sin\theta_0=ma_0$ ...(ii)

Dividing Eq. (ii) by Eq. (i), we get

$\tan\theta_0=\dfrac{a}{\text{g}} \Rightarrow \theta_0=30°$

$T=\dfrac{mg}{\cos 30°}=\dfrac{2mg}{\sqrt{3}}$

222 **(b,c,d)**

Acceleration of particle w.r.t. frame S_1:

$\vec{a}_p-\vec{a}_{s_1}=2\hat{n}$

Acceleration of particle w.r.t. frame S_2:

$\vec{a}_p-\vec{a}_{s_2}=2\hat{m}$

Where $\hat{m}$ and $\hat{n}$ are unit vectors in any directions.

Now relative acceleration of frames:

$\vec{a}_{s_2}=\vec{a}_{s_1}=2(\hat{n}-\hat{m})$

Its magnitude can have Any value between 0 to 4 ms^{-2} depending upon the direction of $\hat{m}$ and $\hat{n}$

223 **(a,c)**

$a_1=\dfrac{2mg-mg}{m}=\text{g}$

$a_2=\dfrac{mg+mg-mg}{2m}=\text{g}/2$

$a_3=\dfrac{2mg-mg}{3m}=\text{g}/3$

Clearly $a_1>a_2>a_3$

224 **(a)**

We give power to real wheel, so fr5iction on rear wheel acts in forward direction. Front wheel is a free wheel on which friction acts in backward direction. Net friction is in forward direction, due to which cycle accelerates

225 **(d)**

The horizontal forces on the man must balance, i.e., the forces exerted by the two walls on him must be equal

The vertical forces can balance even if the forces of friction on the two walls are unequal. The torques due to the forces of friction about his centre of mass must balance. This requires friction on both walls

226 **(b,d)**

Acceleration of $M, a = \left(\frac{F}{M}\right)$

$$\ell = \frac{1}{2}\frac{F}{M}t^2 \quad \Rightarrow t = \sqrt{\frac{2M\ell}{F}}$$

227 **(a,c)**

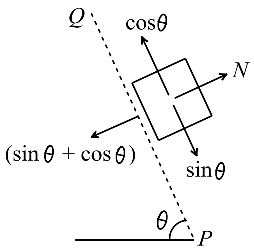
$f = 0, \text{if} \sin\theta = \cos\theta \Rightarrow \theta = 45°$

f towards $Q, \sin\theta > \cos\theta$

$\Rightarrow \theta > 45°$

f towards $P, \sin\theta < \cos\theta$

$\Rightarrow \theta < 45°$



228 **(c)**

Here acceleration of both will be same, but their masses are different. Hence, net force acting on each of them will not be same

229 **(c)**

Work done in moving an object against gravitational force (conservative force) depends only on the initial and final position of the object, not upon the path taken. But gravitational force on the body along the inclined plane is not same as that along the vertical and it varies with the angle of inclination

230 **(c)**

This is because the direction of motion is changing continuously. Hence the velocity is changing and acceleration is being produced. Assertion is true but reason is false

231 **(c)**

According to Newton's second law

Acceleration $= \frac{\text{Force}}{\text{Mass}}$ $i.e.$ If net external force on the body is zero then acceleration will be zero

232 **(d)**

If a body is moved in a closed path the net work done is zero. Gravity and an electrostatic field in vacuum are conservative. But any form of friction prevents the field from being conservative. Also potential energy cannot be associated with frictional forces.

234 **(b)**

Statement 1 is practical experience based; so it is true. Statement 2 is also true but is not the correct explanation of Statement 1. Correct explanation is " there is increase in normal reaction when the object is pushed and there is decreases in normal reaction when object is pulled"

235 **(a)**

In equilibrium, net force on body is zero, therefore, its acceleration a is zero. If the body is at rest, it will remain at rest. If the body is moving with a constant speed along a straight line path, it will continue to do so

236 **(a)**

In the direction of normal reaction, net acceleration zero. Hence, forces in this direction will be balanced.

Hence $N = mg\cos\theta$

237 **(a)**

Acceleration of body sliding down a smooth plane inclination θ is given by

$$\alpha = g\, sin\theta = g\sin 30° = 10 \times \frac{1}{2} = 5\text{ms}^{-2}$$

238 **(c)**

Bearings are used to reduce friction

239 **(e)**

Inertia is the property by virtue of which the body is unable to change by itself not only the state of rest, but also the state of motion

240 **(c)**

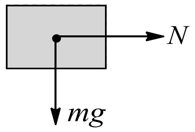
Coefficient of friction$\mu = \tan\theta$. The value of $\tan\theta$ may exceed unity

241 **(a)**

On a rainy day, the roads are wet. Wetting of roads lowers the coefficient of friction between the tyres and the road. Therefore, grip of car on the road reduces and thus chances of skidding increases

242 **(d)**

The FBD of block A is as follows:



The force exerted by B on A is N (normal reaction). The force acting on A are N (horizontal) and mg (weight downwards)

Hence Statement I is false

243 **(c)**

Assertion is true, but the reason is false. The fan continue to rotate due to inertia of motion

244 **(a)**

Contact force is the sum of friction and normal reaction

245 **(c)**

In uniform circular motion, the direction of motion changes, therefore velocity changes

As $P = mv$ therefore momentum of a body also changes in uniform circular motion

246 **(d)**

Pseudo force is applied only for non-inertial frame

247 **(d)**

A frame of reference which is at rest or which is moving with a uniform velocity along a straight line is called intertial frame of reference. But the frame is which Newton's laws of motion are applicable is an intertial frame

248 **(c)**

The apparent weight of a body in an elevator moving with downward acceleration a is given by $W = m(g - a)$

249 **(e)**

When a bicycle is in motion, two cases may arise :

(i) When the bicycle is being pedalled. In this case, the applied force has been communicated to rear wheel. Due to which the rear wheel pushes the earth backwards. Now the force of friction acts in the forward direction on the rear wheel but front wheel moves forward due to inertia, so force of friction works on it in backward direction

(ii) When the bicycle is not being pedalled :

In this case both the wheels move in forward direction, due to inertia. Hence force of friction on both the wheels acts in backward direction

250 **(b)**

According to law of inertia (Newton's first law), when cloth is pulled from a table, the cloth come in state of motion but dishes remains stationary due to inertia. Therefore when we pull the cloth from table the dishes remains stationary

251 **(a)**

The fuel is consumed continuously when the rocket if flying. Hence, the rocket in a flight is a system of varying mass.

252 **(a)**

The wings of the aeroplane pushes the external air backward and the aeroplane move forward by reaction of pushed air. At low altitudes density of air is high and so the aeroplane gets sufficient force to move forward

253 **(e)**

A body subjected to three concurrent forces is found to in equilibrium if sum of these forces is equal to zero

$i.e. \vec{F}_1 + \vec{F}_2 + \vec{F}_3 \dots \dots = 0$

254 **(c)**

Ball bearings, also known as anti-friction bearings are small metallic or ceramic spheres used to reduce friction between shafts and axles in a number of applications.

255 **(c)**

The purpose of bending is to acquire centripetal force for circular motion. By doing so component of normal reaction will counter balance the centrifugal force

256 **(d)**

Acceleration down a rough inclined plane $a = g(\sin\theta - \mu\cos\theta)$ and this is less than g

257 **(d)**

Reference frame attached to Earth is not an inertial frame of reference because Earth is revolving about the Sun, as well as it is rotating about its own axis

258 **(a)**

We know that

Inpulse =change in linear momentum

=final momentum-initial momentum

$= mv\text{-}m(\text{-}v) = 2mv$

259 **(b)**

In uniform circular motion of a body the speed remains constant but velocity changes as direction of motion changes

As linear momentum = mass × velocity, therefore linear momentum of a body changes in a circle

On the other hand, if the body is moving uniformly along a straight line then its velocity remains constant and hence acceleration is equal to zero. So force is equal to zero

260 **(a)**

By lowering his hand player increases the time of catch, by doing so he experience less force on his hand because $F \propto 1/dt$

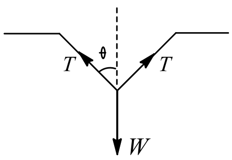
261 **(a)**

$v = \sqrt{\mu r g} = \sqrt{0.1 \times 10 \times 10} = \sqrt{10}\ \text{ms}^{-1}$

Both the assertion and reason are true, and reason is correct explanation of assertion

262 **(a)**

As is clear from figure



$2T\cos\theta = W$

$$T = \frac{W}{2\cos\theta}$$

For the string to become horizontal,

$\theta = 90°, \cos\theta = \cos 90° = 0$

$$\therefore T = \frac{W}{2\cos 90°} = \infty$$

Both the assertion and reason are true and latter is correct explanation of the former

263 **(a)**

Statement II is correct, as it represents Newton's second law as $\vec{F} = \frac{d\vec{p}}{dt}$, from this only we can say for greater value of $\frac{d\vec{p}}{dt}$, force applied has to be more

264 **(b)**

Force needed when breaks are applied

$$f_1 = ma = \frac{mv^2}{d}$$

(v: initial speed, d: distance from wall)

When turn is taken

$$f_2 = ma = \frac{mv^2}{d}$$

Hence, breaks must be applied

265 **(a)**

$F = \frac{\Delta P}{\Delta t}$. If Δt is more, then F will be less

266 **(d)**

Only static friction is a self adjusting force. This is because force of static friction is equal and opposite to applied force (so long as actual motion does not start). Frictional force $= \mu mg$ $i.e.$ friction depends on mass

267 **(d)**

Due to change in normal reaction, pulling is easier

268 **(b)**

By the definition of inertial and nom-inertial frame

269 **(e)**

According to third law of motion it is impossible to have a single force out of mutual interaction between two bodies, whether they are moving or at rest. While, Newton's third law is applicable for all types of forces

270 **(e)**

For uniform motion apparent weight = Actual weight for downward accelerated motion

271 **(d)**

Law of conservation of linear momentum is correct when no external force acts. When bullet is fired from a rifle then both should possess equal momentum but different kinetic energy, $E = \frac{P^2}{2m}$ ∴ Kinetic energy of the rifle is less than that of bullet because $E \propto 1/m$

272 **(a)**

According to Newton's second law of motion $a = \frac{F}{m}$ $i.e.$ magnitude of the acceleration produced by a given force is inversely proportional to the mass of the body. Higher is the mass of the body, lesser will be the acceleration produced $i.e.$ mass of the body is a measure of the opposition offered by the body to change a state, when the force is applied $i.e.$ mass of a body is the measure of its inertia

273 **(d)**

The force acting on the body of mass M are its weight Mg acting vertically downwards and air resistance F acting vertically upward

$\therefore$ Acceleration of the body, $a = \frac{Mg-F}{M} = g - \frac{F}{M}$

Now, $M > m$, therefore, the body with larger mass will have greater acceleration and it will reach the ground first

274 **(b)**

When a body is moving in a circle, its speed remains same but velocity changes due to change in the direction of motion of body. According to first law of motion, force is required to change the state of a body. As in circular motion the direction of velocity of body is changing so the acceleration cannot be zero. But for a uniform motion acceleration is zero (for rectilinear motion)

275 **(b)**

Both the statements are true but reason is not a correct explanation of assertion. Here, friction causes motion

276 **(a)**

In sliding down, the entire potential energy of body is converted only into translational energy. While in rolling motion, some part of potential energy is converted into kinetic energy of rotation and rest into kinetic energy of translation. Therefore, in sliding motion, the velocity acquired by the body is more

277 **(d)**

$F = \frac{dp}{dt}$ = Slope of momentum-time graph

$i.e.$ Rate of change of momentum = Slope of momentum – time graph = force

279 **(a)**

Once the ski is in motion, it melts the snow below it and hence skiing can be performed. To make skiing easier, wax has been put on bottom surface to ski as wax is water repellent and hence reduces the friction between the ski and film of water

280 **(a)**

Due to attraction force, their velocities increase; hence, momentum also increases. For individual particle, gravitational attractive force will be external force

281 **(a)**

$m_{\text{grav}}.\, g - N = m_{\text{inertial}}.\, a$ For freely falling $a = g$.

Since $m_{\text{grav}} = m_{\text{inert}} \Rightarrow N = 0$

282 **(d)**

An inertial frame of reference is one which has zero acceleration and in which law of inertia hold good $i.e.$ Newton's law of motion are applicable equally. Since earth is revolving around the sun and earth is rotating about its own axis also, the forces are acting on the earth and hence there will be acceleration of earth due to these factors. That is why earth cannot be taken a inertial frame of reference

283 **(d)**

Static friction alone is a self adjusting force and not all types of friction. Assertion is false, reason is true

284 **(a)**

Assertion is false, but reason is true. Moment of inertia is not inertia, but rotational inertia

285 **(a)**

(i),(ii) After spring 2 is cut, tension in string AB will not change

$(T_{CD})_i = 4\,mg$

$(T_{CD})_f = m_D\text{g} + m_D.\frac{m_A + m_B - m_C - m_D}{m_A + m_B + m_C + m_D}.\text{g}$

$= 2mg\left(1 + \frac{1}{5}\right) = 2.4\,mg$

Hence T_{CD} decreases

(iii), (iv) After string between C and pulley is cut, tension in string AB will become zero

$(T_{CD})_i = (m_D + m_E)\text{g} = 4\,mg$

Acceleration of C and D blocks is

$(m_C + m_D)\text{g} + m_E\text{g} = (m_C + m_D).\,a$

$a = \frac{6mg}{4mg} = \frac{3}{2}\text{g}, (T_{CD})_f + m_C\text{g} = m_C a$

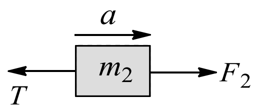
$(T_{CD})_f = 2m\frac{3}{2}\text{g} - 2m\text{g} = mg$

The tension decrease

286 **(d)**

1. Let a be acceleration of two block system towards right, then

$a = \frac{F_2 - F_1}{m_1 + m_2}$



$F_2 - T = m_2.\,a$

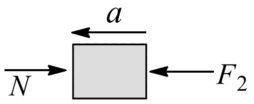
Solving $T = \frac{m_1 m_2}{m_1 + m_2}\left(\frac{F_2}{m_2} + \frac{F_1}{m_1}\right)$

2. Replace F_1 by $-F_1$ in result of (i),

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

3. Let a be acceleration of two block system towards left, then

$$a = \frac{F_2 - F_1}{m_1 + m_2}, F_2 - N = m_2 a$$



Solving, $N = \frac{m_1 m_2}{m_1 + m_2}\left(\frac{F_1}{m_1} + \frac{F_2}{m_2}\right)$

4. Replacing F_1 by $-F_1$ in result of (iii)

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

287 **(c)**

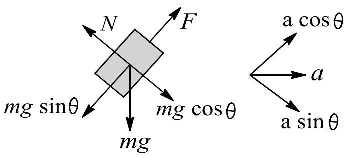
1. Force of friction is zero in (a) and (c) because block has no tendency to move
2. Force of friction is 2.5 N in (b) and (d) because applied force in horizontal direction in both is 2.5 N
3. Acceleration is zero in all cases

(iv) Normal force is not equal of 2g in (c) and (d) because some extra vertical force is also acting

288 **(a)**

Acceleration of the whole system towards right:

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



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

$$\Rightarrow \; F - mg\sin\theta = m\frac{F}{M + m}\cos\theta$$

$$\Rightarrow F = \frac{(M + m)mg\sin\theta}{M + m - m\cos\theta}$$

Pseudo force on m as seen from the frame of M:

$$F_{s_1} = ma = \frac{mF}{m + F} = mg\sin\theta\left(\frac{m}{M + m(1 - \cos\theta)}\right)$$

$$< mg\sin\theta$$

Pseudo force ion M as seen from the frame of m:

$$F_{s_2} = Ma = \frac{MF}{m + F}\left(> \frac{mF}{m + M}\right)$$

$$= mg\sin\theta\left(\frac{M}{M + m(1 - \cos\theta)}\right) < mg\sin\theta$$

Now $mg\cos\theta - N = ma\sin\theta \quad \Rightarrow \quad N = mg\cos\theta - ma\sin\theta$

Hence N is less than $mg\cos\theta$. Hence, it will also be less than $mg\sin\theta$, because $\theta = 45°$

Applying equation on 'm' in horizontal direction:

$$F\cos\theta - N\sin\theta = ma$$

$$\Rightarrow \; F\cos\theta - N\sin\theta = m\frac{F}{M + m}$$

$$\Rightarrow N = \frac{mF}{M + m}\left(\frac{(M + m)\cos\theta - m}{m\sin\theta}\right)$$

Put $\theta = 45°$

$$\Rightarrow \; N = \frac{mF}{M + m}\left(\frac{M + m - \sqrt{2}m}{m}\right) > \frac{mF}{m + M}$$

Normal force between ground and M will be$(M + m)$g. It is greater than $mg\sin\theta$. It is also greater than $\frac{mF}{M+m}$ because $\frac{mF}{M+m}$ is less than $mg\sin\theta$

289 **(c)**

Let the maximum downward displacement of m is x_0., then

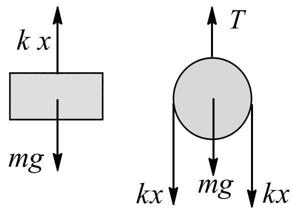
$$\frac{1}{2}kx_0^2 = mgx_0 \quad \Rightarrow \quad x_0 = 2\text{ mg/k}$$

To lift the block (M): $kx_0 = M\text{g} \quad \Rightarrow \quad 2\,mg = Mg$

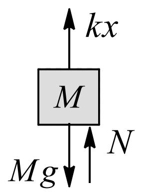
$\Rightarrow \; mg = M\text{g}/2$

Hence (i)-(c)

(ii) When m is in equilibrium



$$kx = mg, \qquad T = 2kx + mg = 3mg = \frac{3M}{2}\text{g}$$



Hence (ii)-(a)

(iii) $N + kx = M\text{g}$

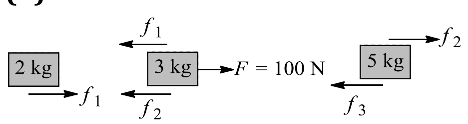
$$N = M\text{g} - kx = Mg - \frac{M}{2}\text{g} = \frac{M}{2}\text{g}$$

Hence (iii)-(c)

4. Tension= $kx_0 = M\text{g} = 2\,mg$

Hence (iv)-(b, d)

290 **(d)**



$$f_{\ell_1} = 0.2 \times 2\text{ g} = 4\text{ N}$$

$$f_{\ell_2} = 0.1 \times 5\text{ g} = 4\text{ N}$$

$$f_{\ell_{32}} = 0.1 \times 10\text{ g} = 4\text{ N}$$

Friction on 3 kg block is towards left and non-zero. Hence

(i)→b, d

$f_{\ell_2} < f_{\ell_3}$ Hence 5 kg block will not move. So net friction on 5 kg will be zero

Hence, **(ii)→(c)**

291 **(b)**

For (i), it is not mentioned whether the object is accelerated or moving with constant velocity. So nothing can be predicted with surety

If no net force is acting along east, then also it can move with constant velocity, and if no force is acting at all, then also it can move with constant velocity

For (ii) and (iii): As the object is accelerated (weather uniform or non-uniform) a force must act on the object in such a manner that a component or whole of the force would be along east, and also the net force must be towards east

For (iv): It is moving with constant velocity, so net force must be zero that implies no force may act on the object

292 **(a)**

Maximum possible acceleration of m: $a_0 = \mu g = 0.5$ g

So (d) matches with all (i), (ii), (iii) and (iv)

Let us assume that m and 2m move together with acceleration a:

$$a = \frac{m_1 g}{3m + m_1}$$

If $a = a_0 \Rightarrow \frac{m_1 g}{3m+m_1} = 0.5g \Rightarrow m_1 = 3m$

So $3m$ is the maximum value of m_1 such that both move together

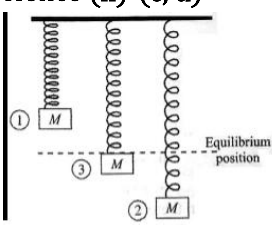
1. $m_1 = 2m < 3m$, hence (i)→(a, d)
2. $m_1 = 3m$ hence (ii)→(a, d)
3. $m_1 = 4m > 3m$, hence (iii)→(b, c, d)
4. $m_1 = 6m > 3m$, hence (iv)→(b, c, d)

293 **(b)**

In figure, 3 is the equilibrium position where velocity is maximum and acceleration is zero. 1 and 2 are the extreme positions where velocity is zero and acceleration is maximum. 1 is the unstretched position

When the block is at position 3, then $mg = kx$. So net force is zero, hence acceleration is zero. But velocity may be either in upward or downward direction

Hence **(ii)-(c, d)**



When the block is between position 3 and 2, then $kx > mg$. So net force is in upward direction, hence acceleration is in upward direction. But velocity may be either in upward or downward direction

Hence **(iii)-(a, d)**

But if the block is at position 2, then velocity is zero and acceleration is in upward direction

Hence **(i)-(a)**

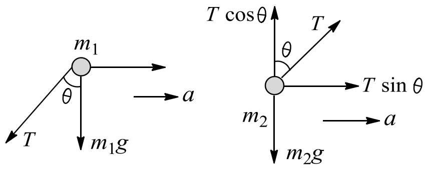
When the block is between position 3 and 1, $mg > kx$. So net force is in downward direction, hence acceleration is in downward direction. But velocity may be either in upwards or downward direction

Hence **(iv)-(b, d)**

294 **(a)**

$F = (m_1 + m_2)a$ (i)

$T \sin\theta = m_2 a$ (ii)



$T\cos\theta = m_2 g \Rightarrow T = m_2 g \sec\theta$ (iii)

From (ii) and (iii), $a = g\tan\theta$

Put in (i), $F = (m_1 + m_2)g\tan\theta$

Net force acting on $m_2 = m_2 a = \frac{m_2 F}{m_1+m_2}$

Force acting on m_1 by wire:

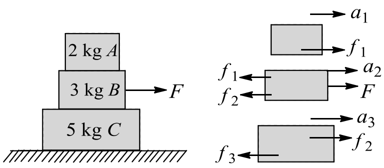
$m_1 g + T\cos\theta = m_1 g + m_2 g$

295 **(c)**

Let f_1, f_2, f_3 represent the friction forces between three contact surfaces $A - B, B - C$ and $C -$ ground, respectively. Limiting val.ues of friction forces at three surfaces are 8 N, 15 N, and 10 N respectively

For relative motion between C and Ground, the minimum force needed is $F = 10$ N

For $F = 12$ N, all the three blocks move together with same acceleration i.e., $a_1 = a_2 = a_3 = a$



$$F - f_3 = (2+3+5)a \Rightarrow a = \frac{12-10}{10}$$

$$= \frac{1}{10}\text{ms}^{-2}$$

$f_1 = 2a = \frac{2}{5}N \Rightarrow f_2 = 12 - f_1 - 3a = 11\ N$

$f_3 = 10$ N

For $F = 15$ N, the situation is similar

For relative motion to start between B and C,

$f_2 \geq f_{L_2}$

$F - f_3 = 10a$ and $F - f_2 = 5a$

$f_2 = F - 5a = F - 5\left[\frac{F - f_3}{10}\right] = \frac{F + f_3}{2}$

$\frac{F + 10}{2} > 15$

$\Rightarrow F > 20$ N (Condition for relative motion to start between B and C)

For relative motion to start between A and B

$f_1^3 f_{L_1} = 8$ N

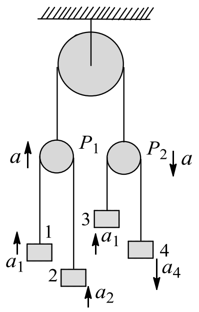
$F - f_1 - f_2 = 3a$ and $f_1 = 2a$

$f_1 = 2\left[\frac{F - 15}{5}\right] > 8$

$f > 35$ N (condition for relative motion between A and B)

296 **(b)**

Let the accelerations of various blocks are as shown. Pulley P_2 will have downward acceleration a



Now $a = \frac{a_1 + a_2}{2} \Rightarrow a_2 = 2a - a_1 > 0$

So acceleration of 2 is upwards

Hence, **(i)→(b, c)**

And $a = \frac{-a_1 + a_4}{2} \Rightarrow a_4 = 2a + a_1 > 0$

So acceleration of 4 is downwards

Hence (**ii**) → (**a**, **d**)

Acceleration of 2 w.r.t. 3:

$a_{2/3} = a_2 - a_3 = a_2 - a_1 = 2(a - a_2) < 0$

This is downwards, hence (**iii**) → (**d**)

Acceleration of 2 w.r.t. 4:

$a_{\frac{2}{4}} = a_2 — a_4 = 4a > 0$

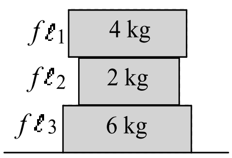
This is upwards. Hence, **(iv)→(c)**

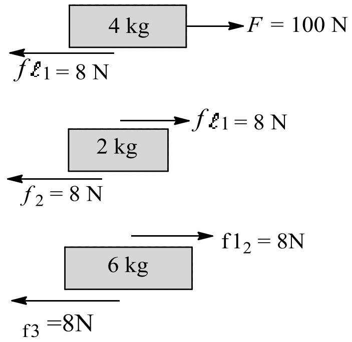
297 **(c)**

$f_{\ell_1} = 0.2 \times 4\text{ g} = 8$ N

$f_{\ell_2} = 0.4 \times 6\text{ g} = 24$ N

$f_{\ell_3} = 0.5 \times 12\text{g} = 60$N





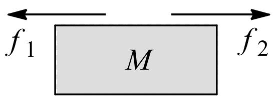
Here only 4 kg will accelerate, 2 kg and 6 kg will remain at rest

298 **(d)**

1. If $m_1 = m_2 = 0$, then there is no force on M in horizontal direction. So M does not accelerate

Hence **(i)-(c)**

2. If $m_1 = m_2 \neq 0$



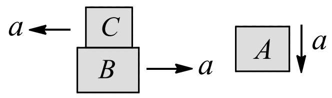
$f_1 < \mu_1\, mg, f_2 < \mu_2 mg$

f_1 And f_2 will be of same magnitude at any time whether the blocks slip on larger block or not, so net force on M is zero. Hence, M does not accelerate. So (ii)-(c)

3. $m_1 > m_2$, here $f_1 > f_2$, hence (iii)-(b, d)
4. $m_1 < m_2$, here $f_1 < f_2$, hence (iv)-(a, d)

299 **(b)**

The direction of acceleration of various blocks are as shown

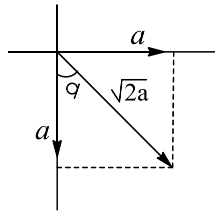


Acceleration of B is towards right, hence (i)→ b.

Acceleration of C w.r.t. B is towards left

Hence (ii)→ a

Acceleration of A w.r.t. C: $\vec{a}_{A/C} = \vec{a}_A - \vec{a}_C = -\hat{a}_j - (-a\hat{\imath}) = a\hat{\imath} - a\hat{\jmath}$ as shown below



Hence (iii)→(c, d), Similarly (iv)→(c, d)

300 **(d)**

Minimum force required just to slide the block = force of static friction

$f = \mu R = \mu\, mg = 0.577 \times 10 \times 10 = 57.7$ N

301 **(c)**

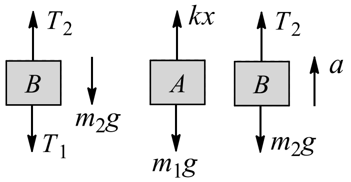
As impulse $= F \times t$

$4.25 = F \times 0.1$

$F = \frac{4.25}{0.1} = 42.5$ N (downwards)

302 **(b)**

Before burning BC, the Free-Body Diagrams are shown in the figure



$T_2 = T_1 + m_2$g (i)

$kx = T_2 = m_1$g (ii)

Where x is extension in the spring. Just after burning, T_1 will become zero, but T_2 will remain same

$T_2 = m_2$g $= m_2 a$

$$\Rightarrow \quad a = \frac{(m_1 - m_2)\text{g}}{m_2}$$

As T_2 remain same, acceleration of block A will still remain zero

303 **(b)**

$T_3 = 20\,t, T_1 = T_2 = 10\,t$

For A to lose contact: $10t = 1$ g $\Rightarrow t = 1$ s

For B to lose contact: $10t = 2$g $\Rightarrow t = 2$ s

For C to lose contact : $20t = 3$g $\Rightarrow t = 1.5\,s$

$a_A = \frac{T_1 - 1\text{g}}{1}$ Velocity of A when B loses contact

$$V_1 = \int_1^2 a_A\,dt = \int_1^2 (10t - \text{g})\ dt = 5\ \text{ms}^{-1}$$

At $t = 2s, a_B = 0,\ a_A = \frac{10\times2-10}{1} = 10\ \text{ms}^{-2}$

$a_{A/B} = a_A - a_B = 10 - 0 = 10\ \text{ms}^{-2}$

304 **(a)**

Area under $F - t$ graph = change in momentum

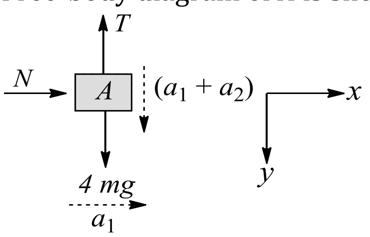
$$\Rightarrow \frac{1}{2}\,F_0(6\times10^{-3}) = \frac{200}{1000}\,[40+20] \quad \Rightarrow \quad F_0 = 4000\ \text{N}$$

305 **(a)**

Let acceleration of block C be a_1 (rightwards) and acceleration of block B be a_2 (leftwards)

Then, acceleration of A will be $(a_1 + a_2)$ downwards and a_1 rightwards

Free-body diagram of A is shown ion the figure

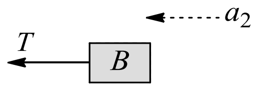


Using $\sum F_x = ma_x$ and $\sum F_y = ma_y$, we get

$N = 4m\,(a_1)$ (i)

And $4mg - T = 4m(a_1 + a_2)$ (ii)

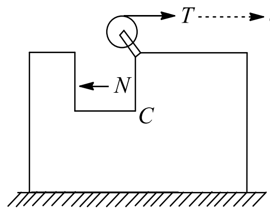
Free-body diagram of B (showing horizontal forces only) is shown in the figure



Using $\sum F_x = ma_x$, we get

$T = 3ma_2$ (iii)

Free body diagrams of C (showing horizontal forces only) is shown in figure



Using $\sum F_x = ma_x$, we get

$T - N = 8\,ma_1$ (iv)

We have four unknowns T, N, a_1 and a_2. Solving these four equations, we get

$$a_1 = \frac{\text{g}}{8} \text{ and } a_2 = \frac{\text{g}}{2}, a_1 + a_2 = \frac{5}{8}\text{g}$$

Thus, acceleration of A is $\frac{\text{g}}{8}$ in horizontal direction and $\frac{5\text{g}}{8}$ in vertical direction

Acceleration of B is $\frac{\text{g}}{2}$ in horizontal direction (leftwards) and acceleration of C is $\frac{\text{g}}{8}$ in horizontal direction (rightwards)

306 **(b)**

For upper block

$a_{\max} = mg = 4\ \text{ms}^{-2}$ and $f_{\max} = 40$ N

1. When $F = 30$ N, as $F < f_{\max}$

So both blocks will move together

$$\therefore \quad a = \frac{F}{M+m} = \frac{30}{35} = \frac{6}{7}\text{ms}^{-2}$$

2. When $F = 250$ N

For upper block: $250 - 40 = 10\,a_1$

$210 = 10a_1 \quad \Rightarrow \quad a_1 = 21\ \text{ms}^{-2}$

For lower block :

$$a_2 = \frac{40}{25} = \frac{8}{5}\text{ms}^{-2}$$

307 **(d)**

From constraint relations, we can see that

$3TX_B = 2TX_A$

$$X_A = \frac{3}{2}X_B \quad \Rightarrow \quad a_A = \frac{3}{2}a_B$$

So let $a_B = a$, then $a_A = 1.5\,a$

Writing equation of motion:

From block A,

$2T = 70a_A = 105a = 3\times35a$

$35a = \frac{2}{3}T$ (i)

From block B,

$300-3T=35a_B=35a$ (ii)

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

$300-3T=\dfrac{2T}{3}$

$\Rightarrow\ 900-9T=2T\ \Rightarrow\ 900=11\,T$

$T=\dfrac{900}{11}$ N

$a_A=\dfrac{180}{77}\text{ms}^{-2}$ and $a_B=\dfrac{120}{77}\text{ ms}^{-2}$

308 **(d)**

As the monkey moves downwards with respect to rope with an acceleration$b$, its absolutre acceleration is$a+b$, where a is the acceleration of rope. Therefore, equations of motion are

$mg-T=m(a+b)$ (i)

$T-\mu M\text{g}=Ma$ (ii)

Putting the value of T from Eq. (ii) into Eq. (i), we get

$(m-\mu M)\text{g}=(M+m)a+mb$

$\Rightarrow\ \dfrac{m(\text{g}-b)-\mu M\text{g}}{(M+m)}=a$

$T=\mu M\text{g}+\dfrac{Mmg-Mmb-\mu M^2\text{g}}{M+m}$

$=\dfrac{\mu M^2\text{g}+\mu Mmg+Mmg-Mmb-\mu M^2\text{g}}{M+m}$

$=\dfrac{Mm(\mu\text{g}+\text{g}-b)}{M+m}$

309 **(b)**

$f_{l_1}=0.25\times 4=1\ N,$

$f_{l_2}=0.25\times(4+8)=3\ N$

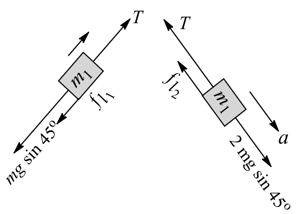
$F=f_{l_2}=3$ N for constant velocity

310 **(b)**

$T-mg\sin 45^\circ-f_{l_1}$

$=ma,\ \ 2\ mg\ \sin 45^\circ-T-f_{l_2}$

$=2\ ma$



Where $f_{l_1}=\mu_2 2mg\cos 45^\circ=2mg\cos 45^\circ/3$

And $f_{l_2}=\mu_2 2mg\cos 45^\circ=2mg\cos 45^\circ/3$

Now we get $a=-\frac{g}{9\sqrt{2}}$

This is negative, which is not possible. Hence $a=0$

311 **(c)**

Net force $F=\sqrt{F_1^2+F_2^2}=\sqrt{41}\ N$

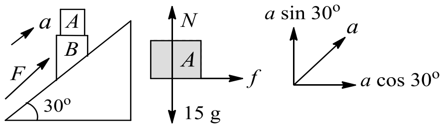
$f_l=0.4\times 10\text{ g}=40\ N, f_k=0.3\times 10\text{ g}=30$ N

Net force is less than f_l, hence

Required friction force=applied force= $\sqrt{41}$ N

312 **(a)**

$500-55\text{ g}\sin 30^\circ=55\ a\ \Rightarrow\ a=\dfrac{45}{11}\text{ms}^{-2}$



$N-15g=15\ a\sin 30^\circ$

$N=15\left[10+\dfrac{45}{11}\times\dfrac{1}{2}\right]=\dfrac{265\times 15}{22}$

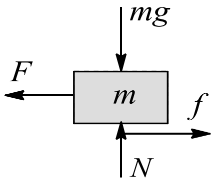
$f=15a\cos 30^\circ=15\times\dfrac{45}{11}\dfrac{\sqrt{3}}{2}$

For A not to slide on B: $f\le f_\ell$

$\Rightarrow\dfrac{15\times 45}{11}\times\dfrac{\sqrt{3}}{2}\le\mu\left(\dfrac{265\times 15}{22}\right)$

$\Rightarrow\ m\ge\dfrac{9\sqrt{3}}{53}=0.294$

313 **(b)**



Assuming systems move together there is no sliding, acceleration of the system

$a=\frac{F}{(5+10)}=\frac{F}{15}$ (i)

FBD of m

FBD of M: $f-F=ma=10\left(\frac{F}{15}\right)$

$\Rightarrow\ f=F\left(1+\frac{10}{15}\right)=\frac{5}{3}F$ (ii)

If there is no sliding, $F\le\mu_S N$

$F\left[\dfrac{5}{3}\right]\le 0.4\times 10\times 10\ \ \Rightarrow F\le 24$ N

From (i) $a=\frac{F}{15}=\frac{24}{15}=1.6\text{ ms}^{-2}$

314 **(c)**

$0.5t=\mu\,mg\ \left(1+\dfrac{m}{M}\right), t=12\ s$

$\Rightarrow\ \mu=0.2$

315 **(d)**

Force in spring can't change abruptly whereas tension in string can change

When PQ is cut, no effect on the forces acting on C, hence its acceleration remains zero

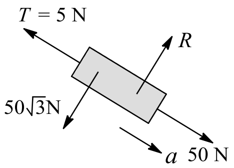
316 **(d)**

$mg\sin 30-T=ma$

$50-5=10\ a$

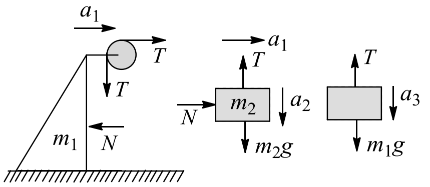
$a=4.5\text{ ms}^{-2}$

$a_{P_4}=\dfrac{0+4.5}{2}=2.25\text{ ms}^{-1}$



317 **(a)**

Free-body diagrams



Constraint relations:

$x_1 = x_2 + x_3$

$a_1 = a_2 + a_3$

Equation of motion:

$T - N = m_1 a_1$ (i)

$N = m_2 a_1$ (ii)

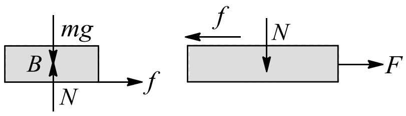
$m_2\text{g} - T = m_2 a_2$ (iii)

$m_3\text{g} - T = m_3 a_3$ (iv)

Using above equation, we can calculate the values

318 **(d)**

Free-body diagrams:



Let both blocks move together

Acceleration of blocks, $a = \frac{F}{(m+M)}$

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

If both the blocks moves together, $f \le \mu m\text{g}$

$$\frac{mF}{(m+M)} \le \mu\, m\text{g}$$

$F \le \mu(m+M)\text{g}$

If the begins to slide then, $F = \mu(m+M)\text{g}$

$a_m = \frac{f}{m} = \mu g$ (towards$+x$ direction)

$a_M = \frac{F-\mu m g}{M}$ (towards $+x$ direction)

$$\vec{a}_{m,M} = \vec{a}_m - \vec{a}_M = \mu\text{g} - \left(\frac{F-\mu m\text{g}}{M}\right)$$

$$= \frac{\mu(m+M)\text{g} - F}{M}$$

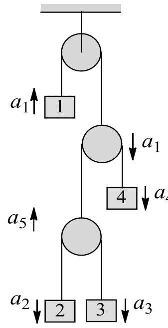
If the cube falls the plank, it will cover a distance ℓ

$$-\ell = \frac{1}{2} a_{mM} t^2 \Rightarrow t = \sqrt{\frac{2\ell}{a_{M,m}}}$$

$$= \sqrt{\frac{2\ell M}{F - \mu(m+M)\text{g}}}$$

319 **(a)**

Acceleration of different objects is shown in figure. All the acceleration are w.r.t. ground



Given : $a_3 = a_4$ (i)

$a_2 + a_1 = 1$ (ii)

$a_3 + a_1 = 5$ (iii)

From figure, we can write

$-a_5 = \frac{a_2+a_3}{2}$ (iv)

$a_1 = \frac{a_4-a_5}{2}$ (v)

Solving the above equations, we get

$a_1 = 2\text{ ms}^{-2}, a_2 = -1\text{ ms}^{-2}, a_3 = a_4 = 3\text{ ms}^{-2}$

320 **(c)**

$h = \sqrt{l^2 - r^2} = 1\text{ m}$

Time period: $T_0 = 2\pi\sqrt{\frac{h}{\text{g}}} = 2\pi\sqrt{\frac{1}{10}} = \frac{2\pi}{\sqrt{10}}\text{s}$

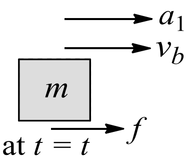
321 **(d)**

$T\cos\theta = mg, \qquad T\sin\theta = mv^2/r$

Squaring and adding both, we get the answer

322 **(c)**

For $t < t_0$: $f = \mu\, mg\, a_1 = \frac{f}{m} = \mu\text{g}$



Velocity of block at any time:

$v_b = v_1 + a_1 t$

$\Rightarrow v_b = v_1 + \mu\,\text{g}t$

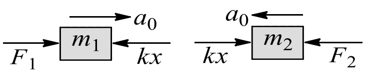
Velocity of plank at any time: $v_p = v_2 + at$

At $t = t_0$, both velocities are same

$$v_1 + \mu\,\text{g}t_0 = v_2 + at_0 \Rightarrow t_0 = \frac{v_2 - v_1}{\mu\text{g} - a}$$

323 **(b)**

Let x be the compression in spring at any time



$F_1 - kx = m_1 a_0, F_2 - kx = m_2 a_0$

Solve to get b: $a_0 = \frac{F_1-F_2}{m_1-m_2}$

and $kx = \frac{m_1F_2 - F_1m_2}{m_1-m_2}$

Just after m_2 is removed

$$a_2 = \frac{kx}{m_2} = \frac{F_2 - m_2a_0}{m_2} = \frac{F_2}{m_2} - a_0$$

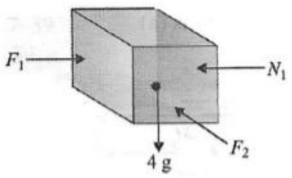
324 **(c)**

The force acting on the block are F_1, F_2, mg, normal contact force and friction force. Here frictional force won't act along vertical direction as the component of resultant force along the surface acting on body is not along vertical direction and direction of the friction force is either opposite to the motion of block (direction of acceleration of resultant force along the surface if it is not moving)

$N_1 = 300$ N

So, $f_L = mN_1 = 0.6 \times 300 = 180\ N$

Resultant of 4 g and F_2 is 107.7 N making an angle of $\tan^{-1}\left(\frac{2}{5}\right)$ with the horizontal. As force applied $F_2 = 100$ N is less than f_L, the block doesn't move and friction is static in nature



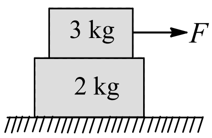
$f = 107.7$ N making an angle of $\tan^{-1}\left(\frac{2}{5}\right)$ with the horizontal in upward direction

325 **(b)**

As acceleration is coming negative for both the possible direction of motion, it means net applied force is not enough to cause the motion of system or to overcome the limiting friction force

326 **(d)**

From the data given we can find the limiting friction force for the two surfaces



$f_{L_1} = 0.5 \times 3 \times 10 = 15$ N

$f_{L_2} = 0.2 \times 5 \times 10 = 10$ N

For $F < f_{L_2}$

Both the blocks remain at rest and $f_1 = F, f_2 = f_1$ and $a_1 = a_2 = 0$. For $F > f_{L_2}$ and F is less than a certain value say F_1, the motion starts at lower surface but both the blocks continue to move with same acceleration. The friction on lower surface becomes kinetic in nature

Here, $a = a_1 = a_2 = \frac{F - f_{k_2}}{5}$ ms^{-2}

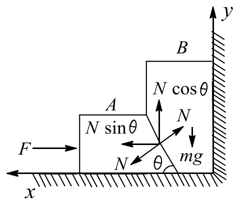
$F - f_1 = 3\,a$ and $f_1 - f_k = 2a$

All these equations give $f_1 = \frac{2F + 3f_{k_2}}{5}$ for relative motion to start between two bodies, $f_1 \geq f_{L_1}$.

$F \geq 30$ N. So minimum value of F to cause relative motion between blocks is 30 N. For $f = 12$ N, $f_1 =$ 7.8 N

327 **(c)**

For equilibrium of block A



$F = N \sin\theta$

$N = F/\sin\theta$

To lift block B from ground

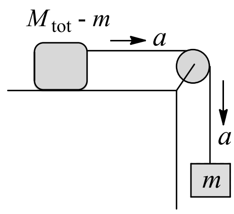
$N\cos\theta \geq mg \Rightarrow \dfrac{F}{\sin\theta}\cos\theta \geq mg$

$F \geq mg\tan\theta = mg\left(\dfrac{3}{4}\right)$

So, $F_{\min} = \frac{3}{4}mg$

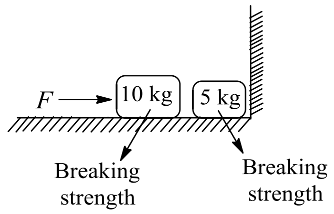
328 **(a)**

$a = \left(\dfrac{m}{M_{tot}}\right)g$



329 **(d)**

If $F = 20$ N, 10 kg block will not move and it will not press 5 kg block So $N = 0$



330 **(b)**

$\omega = \dfrac{2}{\pi}2\pi = 4$ rad s^{-1}

$T = m\omega^2\ell = m(4)^2\ell = 16m\ell$

331 **(d)**

Initially velocity: $u = 0$

$I = \displaystyle\int F\,dt \Rightarrow m(v - u) = \int_0^t (6t - 2t^2)\,dt$

$\Rightarrow 2v = 3t^2 - \dfrac{2}{3}t^3$

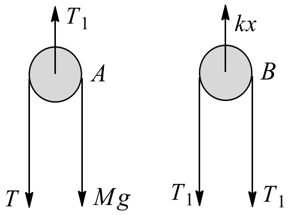
Put $v = 0$, we gte $t = 4.5$ s

332 **(a)**

Let m_1 and m_2 do not accelerate up or down, then $F_1 = m_1 g, F_2 = m_2 g$. But $m_1 \neq m_2$, so $F_1 \neq F_2$ Hence net horizontal force on M is $F_1 - F_2$. So M cannot be in equilibrium. If M acceelrates horizontally, then m_1 and m_2 also accelerate horizontally

333 **(a)**

$T = M\text{g}$



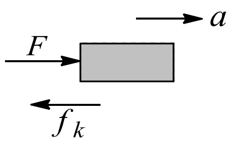
$T_1 = T + M\text{g} = 2\,M\text{g}$

$Kx = 2\,T_1$ or $x = \dfrac{2T_1}{K} = \dfrac{4M\text{g}}{K}$

334 **(c)**

$f_\ell = f_k = 0.5 \times 2\,g = 10\,N$

Initially $F = 20\,N > f_\ell$, so the block will start accelerating immediately



At any time t: $F = 20 - 2t$

Acceleration : $a = \frac{20-2t-f_k}{m} = \frac{10-2t}{m}$ (i)

For $a = 0, \frac{10-2t}{2} = 0 \quad \Rightarrow t = 5\text{ s}$ (ii)

From (i) $\frac{dv}{dt} = \frac{10-2t}{2} = 5 - t$

$\displaystyle\int_0^v dv = \int_0^1 (5-1)\ dt \ \Rightarrow\ v = 5t - \frac{t^2}{2}$

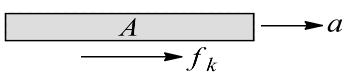
Let us see when the velocity becomes zero, For this:

$5t - \frac{t^2}{2} = 0 \ \Rightarrow\ t = 10\text{ s}$

We see that at $t = 10$ s, also$F = 0$. So the block has no tendency to move. Hence, acceleration is zero at this time. Now the block will not move from $t = 10$ s to 15 s, because for this magnitude of $F < 10$ N. so block will remain at rest from $t = 10$ s to 15 s or acceleration is zero from 10 to 15 s

335 **(c)**

Since there4 is no friction between A and B, B will remain at rest



$f_k = u(2+2)\text{g} = 0.1(2+2)\text{g} = 4\text{ N}$

Acceleration of A: $a = \frac{f_k}{m} = \frac{4}{2} = 23\text{ ms}^{-1}$

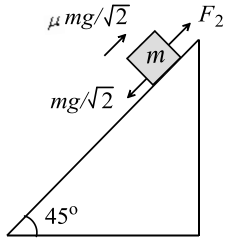
For B to fall off A: $S = ut + \frac{1}{2}at^2$

$\Rightarrow 4 = 0 \times t + \dfrac{1}{2}2t^2 \ \Rightarrow\ t = 2\text{s}$

336 **(5)**

$F_1 = \dfrac{mg}{\sqrt{2}} + \dfrac{\mu mg}{\sqrt{2}}$

$F_2 = \dfrac{mg}{\sqrt{2}} - \dfrac{\mu mg}{\sqrt{2}}$



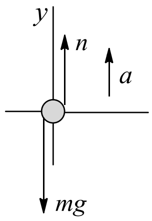
$F_1 = 3F_2$

$1 + \mu = 3 - 3\mu \Rightarrow 4\mu = 2 \Rightarrow \mu = \dfrac{1}{2}$

$N = 10\mu \Rightarrow N = 5$

337 **(6)**

Consider the forces on the person:



$\sum F_y = ma_y$

$n - mg = ma$

$n = 1.6\,mg$ so $a = 0.60\text{ g} = 6\text{ ms}^{-2}$

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

$\Rightarrow\ v^2 = 0^2 + 2 \times 6 \times 3$

$v = 6\text{ ms}^{-1}$

338 **(6)**

Force of friction between the two will be maximum i.e.,

μmg. Retardation of A is $a_A = \frac{\mu m\text{g}}{m} = \mu\text{g}$

And acceleration of B is $a_B = \frac{\mu m\text{g}}{2m} = \frac{\mu\text{g}}{2}$

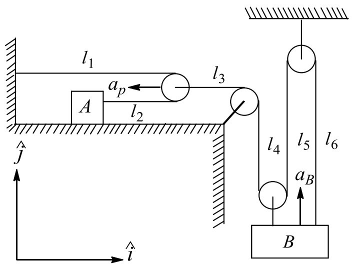
Acceleration of B relative to A is $a_{BA} = a_A + a_B = \frac{3\mu\text{g}}{2}$

Substituting, $\mu = \frac{1}{2}$; $a_{BA} = \frac{3\text{g}}{4}$

339 **(2)**

$\ell_1 + \ell_2 = C \ \Rightarrow\ \ell_1' + \ell_2' = 0$

$\Rightarrow\ -a_p + \left(12 - a_p\right) = 0 \quad \Rightarrow\ a_p = 6\,ms^{-2}$

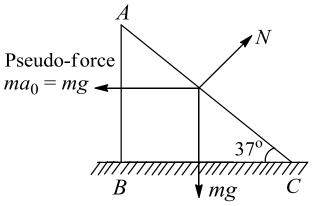


$\ell_3 + \ell_4 + \ell_5 + \ell_6 = C \ \Rightarrow\ \ell_3' + \ell_4' + \ell_5' + \ell_6' = 0$

$a_P - a_B - a_B - a_B = 0 \ \Rightarrow\ a_P = 3a_B \ \Rightarrow\ a_B = 2\text{ ms}^{-1}$

340 **(1)**

Drawing free-body diagram of block with respect to plane. Acceleration of the block up the plane is



$$a = \frac{mg\cos 37° - mg\sin 37°}{m} = g\left(\frac{4}{5} - \frac{3}{5}\right)$$
$$= 2\ \mathrm{ms^{-2}}$$

Applying, $s = \frac{1}{2}at^2$ we get

$$\Rightarrow\ t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 1}{2}} = 1\ \mathrm{sec}$$

341 **(8)**

Since $mg\sin 37° > \mu\, mg\cos 37°$, the block has a tendency to slip downwards

Let F be the minimum force applied on it, so that it does not slip. Then,

$N = F + mg\cos 37°$

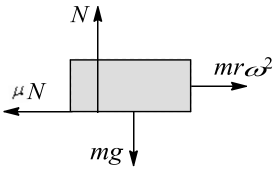
$\therefore\ \ mg\sin 37° = \mu N = \mu(F + mg\cos 37°)$

or $F = \frac{mg\sin 37°}{\mu} - mg\cos 37°$

$$= \frac{(2)(10)(3/5)}{0.5} - (2)(10)\left(\frac{4}{5}\right) = 8\ \mathrm{N}$$

342 **(1)**

$N = mg, \mu N = mr\omega^2$



$$\mu mg = m\,2\sin\theta\,\omega^2\ \Rightarrow\ \omega = \sqrt{\frac{\mu g}{\sin\theta}}$$
$$= \sqrt{\frac{0.1 \times 10}{2 \times \sin 30°}} = 1\ \mathrm{rad\ s^{-1}}$$

343 **(5)**

Denote the common magnitude of the maximum acceleration as$a$. For block A to remain at rest with respect to block A to remain at rest with respect to block $B, a \le \mu_s g$. to be largest. The tension in the cord is then

$$T = (m_A + m_B)a + \mu_k g(m_A + m_B)$$
$$= (m_A + m_B)(a + \mu_k g)$$

This tension is related to the mass m_C (largest) by $T = m_C(g - a)$.Solving for m_C yields

$$m_C = \frac{(m_A + m_B)(\mu_s + \mu_k)}{1 - \mu_s}$$
$$= \frac{(1.5 + 0.5)(0.6 + 0.4)}{1 - 0.6} = 5\ \mathrm{kg}$$

344 **(2)**

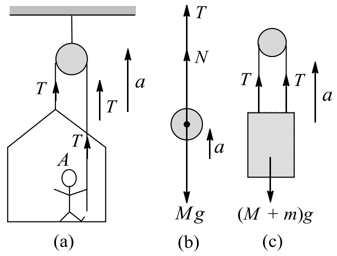
Let M = mass of painter =10 kg

m = mass of crate=25 kg

Let F_A be the action force exerted by painter on crate, reaction force exerted by crate on man

$N = F_A = 450$ N

The free-body diagram of painter is shown in figure (b)



Therefore, equation of motion of painter is

$N + T - Mg = Ma$ (i)

The equation of motion of whole system is

$2T - (M + m)g = (M + m)a$ (ii)

Multiplying (i) by 2, we get

$2N + 2T - 2Mg = 2Ma$ (iii)

Subtracting (ii) from (iii), we get

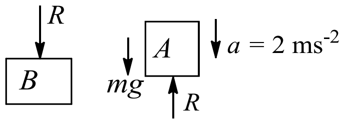
$2N - 2Mg + (M + m)g = (2M - M - m)a$

or $2N - (M - m)g = (M - m)a$

$$a = \frac{2N - (M - m)g}{M - m}$$
$$= \frac{2 \times 450 - (100 - 25) \times 10}{100 - 25} = \frac{900 - 750}{75}$$
$$= 2\ \mathrm{ms^{-2}}$$

345 **(4)**

Let A apply a force R on B



Then B also applies an opposite force R on A as shown in figure

For A:

$mg - R = ma$

$\Rightarrow R = m(g - a) = 0.5[10 - 2] = 4$ N

346 **(4)**

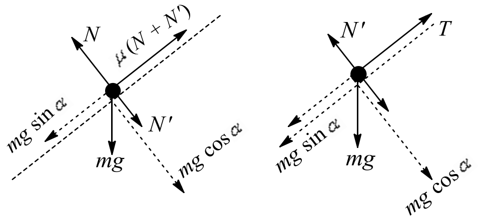
Since A tends to slip down, frictional forces act on it from both sides up the plane

Let N be the reaction of the plank on A and N' be the mutual normal action-reaction between A and B

From the free-body diagram of A

$N' + mg\cos\alpha = N$ and $mg\sin\alpha = \mu(N + N')$

From the free-body diagram of B



$N6'' = mg\cos\alpha$

$mg\sin\alpha + \mu N' = T$

$\therefore \;\; 2\,mg\cos\alpha = N$

and $\;mg\sin\alpha = \mu(2\,mg\cos\alpha + mg\cos\alpha)$

or $\mu = \frac{1}{3}\tan\alpha = \frac{1}{3}\times\frac{3}{4} = 0.25$ or 1/m=4